ATLS PROVIDES A STRUCTURE?

You're an emergency physician, and what does everyone think we do best? Trauma! It makes sense that a trauma iBook was high on the list of RCEMLearning's priority releases, and we hope you're not disappointed. Please let us know what you think of this collating and archiving structure, and whether we should do it again!

This iBook is structured according to the ATLS 10th edition chapters. Why have we done this when ATLS (Advanced Trauma Life Support) is often considered "archaic" and not to be recommended. Well, we've done it because I firmly believe that ATLS provides a core basis and structure for everyone to use to provide excellent trauma care. Hand on heart, I've not been in many hospitals where the ATLS principles have been followed for every trauma case.

The majority of times that doesn't matter. Sometimes it does. Once you've got ATLS principles firmly ingrained in your head and your practice, then newer and different trauma care and knowledge can be used - and RCEMLearning has produced many suggestions for how and what that advanced trauma care can be. So ATLS provides a structure, and a framework to hang your extra knowledge on - just like it is providing a structure for the RCEMLearning Trauma book.

If you're new to trauma, read this book, and complete your ATLS course. It'll stand you in good stead. Other courses do exist, and are fabulous too. The European Trauma Course builds on parallel assessment skills to provide further knowledge. The Nurses have their own specific courses.

Enjoy the iBook!
TEACHING AND PASSING ATLS

Authors: Charlotte Davies / Nina Whittle
SURVIVING NEW ATLS — THE INSTRUCTOR’S VIEW

Teaching “old” ATLS was a bit of a doddle. You prepared a lecture (using their slides), delivered it, and ate bags of food whilst everyone else delivered their lecture. Then, supervised some practical sessions, worked hard at moulage, and everyone passed. Then came “new” ATLS – no lectures! Woohoo. But, there were many other things that changed:

- Content - base excess is now part of categorising shock. Needle decompression is in the 5th intercostal space midaxillary line. And more.

- No lectures – so you have to make sure your students know what they need to know by assessing them throughout the practical stations.

- Scenarios for everything – so there’s no hiding. EVERYONE teaches a scenario where there’s a bleeding patient and you demonstrate how to put on a tourniquet...how to put on a pelvic binder...how to put on a splint – you need to know

That means that you have to be prepared before you come to the course, and there’s no chance to rest. But it also means that the course is better, and much improved. You talk things through in a much more real time fashion. Everyone is engaged, and gets a chance to practice.

There’s a few things that I always forget in ATLS, and I have a little crib sheet to make sure next time, I just rock up and teach, and have immersive fun!

Pendleton Plus: Hayley Allen, the ATLS educator has written a blog on this. Which is great to read, as I can never find pendleton plus in my pages of ATLS instructors manual!

Four Stage Approach: This can take a bit of time to go through, but does consolidate skills well.
### Kendrick Splints

**MEASURE**
Groin to one section length below foot

**GROIN:**
Apply black groin strap
This should be as high up as possible

**ANKLE:**
Apply ankle strap
Padded part sits behind the ankle
Hook the yellow end over the pole end
Tighten with the green strap

**TRACTION:**
Pull the red ankle strap
Analgesia may be needed

**STRAP:**
Apply the other Velcro straps
Red at the top of the thigh
Yellow above the knee
Green on the lower leg

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Kendrick Splints – these are well described here. I’m not sure I’ve ever put one on for real as we don’t have them in my ED!

- Pelvic Splints – there’s a great consensus statement on pelvic splints [here](#), but sometimes you just need to know how to use the one you’ve got!

- 1. **Improvise** – a bed sheet would work if necessary, but you must remember to also tie the patient’s ankles together.

- 2. A **SAM splint** is blue, one size, with a big orange buckle. Apply the splint, then pull the orange buckle until it clicks. It shouldn’t let you over squeeze.

- 3. SAM or T-pod – log roll on, or scoop onto splint. Then position and tighten.
PELVIC SPLINT PLACEMENT

- Those of you who use pelvic splints will know the importance of where exactly it is placed. For those unfamiliar it is NOT placed high where you fasten your trousers it’s much lower over the hips (greater trochanter) as shown below! Buckle to balls is one way of remembering it!

— Active First Aid (@Active_FirstAid) January 2, 2018

Splint to Skin

SAM Splint
Clicks when its tight enough

T-pod
Measure for a 6 - 8 cm gap
Cut the excess
Attach the velcro
Pull on the cord
Wrap the cord around the plastic hooks
IO Insertion – ATLS sensibly teaches humeral insertion. But whilst I know where to put the needle, I can never quite remember the official landmarks.

### Humerus

**ADDUCT elbow**

FEEL for surgical neck of humerus (slide up anterior shaft, feel a bump)

1cm above

### Tibia

**BEND knee**

2 finger breadths below patella

1-2 cm medial to tibial tuberosity

@RCEMLearning

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**The Student’s Perspective**

Of course there are differences between the ALS and the new style ATLS. The obvious difference is the medical causes for a cardiac arrest that you have to consider in ALS such as a PE are not there in the ATLS – but this does not mean that it is not relevant and only now really can I see the importance of the systematic approach and how both courses are really intertwined when treating a patient who is in peri or active cardiac arrest.

I have completed (and passed) the ALS four times within my career but it was only on the most recent occasion that I actually felt confident about passing. As a result I was more relaxed about it and concentrated more on the detail, understanding more of the course content and the language used, making sure that I didn’t have a panic attack during the ABG session (which has happened before). During the MCQ paper I was confident with myself and my answers and I was so proud that finally I gained instructor potential.
Now fast forward a month and the completion of the ATLS (old 3 day course). I have to admit that I started off really interested and going through the book, but this wavered and towards the end of it, the work felt relentless and I was wondering “What’s the point of going through the book when they are going to provide us with the information in the lectures?”. So I stopped reading. This was mistake number one.

The course generally went well and I passed the practical assessment but then it came to the MCQ. I could feel the panic setting in because I was not as prepared as I should have been. Mistake number two, losing concentration. Mistake number three was looking around to see what answers other people have put, panicking that I had not put the same and changing my answers. Needless to say I failed, not only on this occasion but the following three attempts as I was not reading the questions properly and was getting flustered.

When I was informed that I would need to complete the new eATLS I was disappointed as all the modules were online and there was no hard-copy book that I could carry around with me, but actually I think this was a big factor in helping me to pass this time around.

All modules and the pre course MCQ had to be completed at least 24 hours prior to the course start date. This meant that I could not get out of completing the components and it paid off. In addition I located some old ATLS papers via the internet and although they did not have the answers I practiced them and went through the answers with my supervisor.

When it came to the MCQ I was like I was at the ALS: I concentrated, forgot about anyone else in the room and as the answers came up I placed a cross next to the ones that I knew were wrong therefore leaving me with the possible ones to work through.

I suppose in a long-winded way my tips for completing both the ALS and ATLS are to:

• Don’t underestimate the amount of time that it takes to revise and understand the information that has been provided therefore start revision as early as possible.

• Use resources available to you such as colleagues to clarify things that you do not understand – do not leave this until you get to the course.

• Use the internet or ask the course provider if there are any past papers for you to practice on. The wording of the questions is what catches most people out.

• Block everyone else out of the room and from your brain. You have to remain focused. Remember it is only for 45 minutes.

• Mark off the answers that you know are wrong as you are going through them to reduce the selection of possible answers.

• Remember to breathe and enjoy your learning as I believe you will remember and take more in this way.

Please, share with us any of your thoughts, comments, tips and suggestions for teaching and learning basic trauma care! We’re on twitter @RCEMLearning
INITIAL ASSESSMENT AND MANAGEMENT

Author: Charlotte Davies / Editor: Nikki Abela / Codes: HMP3, CMP3 / Published: 31/07/2018
When you tell people you work in the ED, they invariably ask you for your great stories but they also ask you for help and advice when needed. Most of the time, you can confidently say it’s not life threatening, go and speak to your GP. But what if it is? You know how to treat cardiac arrest and anaphylaxis but ED is likely to be your first exposure to trauma. So when your neighbour falls down the stairs, you need to remember a systematic approach so that you can confidently manage trauma whilst you wait for equipment, and specialists to arrive. If you’re in the department, the principles remain the same!

If you ask most people to think up a trauma scenario, it is likely to involve multiple injuries, high velocity injuries (cars, planes, entrapment) and an unwell patient. In reality, trauma is less dramatic falling down the stairs, falling off the monkey bars or maybe falling off a push bike. Whether it is major trauma, silver trauma, or minor trauma, the same logical process should be used. In some circumstances it takes a long time to finish assessing the airway. Sometimes, the whole process can be followed very quickly. This blog post isn’t going to turn you into a trauma expert, but it will remind you of the basics – and often doing the basics well is what saves lives.

Scene Safety

Scene safety always seems obvious, but is frequently overlooked. Think about the danger to yourself, then bystanders, and then the patient. Consider whether you are dressed appropriately, and fit to proceed. Think about other traffic; cars, bikes and other helpful bystanders. Think about broken glass, debris, falling walls. If it’s not safe, or you’re not sure, don’t put yourself in danger.

If you’re in the department, your safety should be assured. What if the person who stabbed your trauma patient is following them in? More realistically, is it safe for you to manage this patient solo do you need to ask for help? Trauma call?
Initial assessment and management

Mechanism of Injury

As you approach any trauma patient, think about what forces are involved. If their car is very smashed, there will be lots of energy involved and the patient must go to hospital as soon as possible. If they’ve fallen from the monkey bars, the forces are lower. Elderly people need really low levels of energy to sustain significant injuries, falling down the stairs is likely to break lots of bones. Falling against a wall could break a rib. Be suspicious and have a read of the London elderly trauma guidelines or the HECTOR handbook to make you think. Children are very good at bouncing but often appear well until suddenly they’re not. Observe carefully, and read our post on paediatric anatomy to make you think of some of the differences.

Catastrophic Haemorrhage

Is there any haemorrhage that is going to kill the patient if its not dealt with immediately? Are they pumping all of their circulation out of an amputation or a significant wound? If so, put pressure immediately on the wound. If you don’t have appropriate personal protective equipment, ask the patient to apply the pressure! A tourniquet might be useful here. In mass casualty situations, tourniquets are recommended. Why not look at the citizen aid app to remind yourself about what steps to take.

Airway

Most patients we see will have a patent airway, but you still need to assess it as part of your primary survey. If the patient needs their airway opening make sure they are in resus and your seniors are aware! We normally use a head tilt and chin lift, but if trauma is involved, we should use a jaw thrust. Check out this module for a reminder of basic airway manoeuveres.

An open airway is the most important thing for everyone, so although a head tilt chin lift would move the c-spine, an open airway gives your patient the greatest chance of survival, so if a jaw thrust isn’t working and help isn’t there yet its better than doing nothing.

C-Spine Immobilisation

If you are worried the patient has damaged their c-spine, now is the time to start quickly manually immobilising it. Put your hands around their head to keep it still. Unless there’s lots of help available, don’t faff around with collars at this point. There are still life threatening injuries you need to look for and the benefit of collars is controversial. Manually immobilise until help has arrived!

Breathing

You need to make sure your patient is breathing. If they’re not start CPR. Assuming they are, check their respiratory rate. Check the saturations if available and put on high flow oxygen what ever the result and your seniors can remove it later. Look at the chest for any open sucking chest wounds. These may suck more air in and cause a tension pneumothorax. Cover them up with a gauze dressing. Then have a quick look to check both sides of the chest are moving, if one side isn’t moving and you’re pre-hospital, make sure your ambulance is on the way.

If you’re in hospital, think could this be a tension pneumothorax? If it could be (hyperresonant to percussion, absent breath sounds), perform a needle decompression. If you don’t think it could be, make sure you have urgent senior help and arrange a chest x-ray.

Think could this be a massive haemothorax (dull to percussion, likely shocked patient). Make sure senior help is arriving, move on to circulation, and prepare for chest drain insertion.
There are six life threatening chest injuries traditionally taught, although they are going out of fashion. I like the mnemonic TOMCAT check for airway obstruction, tension pneumothorax, open pneumothorax, massive haemothorax, flail chest or cardiac tamponade.

**Circulation**

Have a look for any bleeding. If you can see any obvious bleeding, apply pressure to stop the bleeding as you would normally.

Check a pulse rate.

Traditionally, there can be bleeding in five places; the floor (external haemorrhage), and four more, chest, abdomen, pelvis, and long bones. Bleeding in the chest has been (hopefully) identified in your B assessment. Inspect the abdomen for bruising and palpate for any guarding. This will guide you towards intra-abdominal bleeding. The pelvis can bleed a lot. If you think the patient may have a pelvic injury, figure a way to splint the pelvis and close the book to stop the bleeding. In hospital, this will be application of a pelvic splint. Pre-hospital you may need to tie your bed sheets around the patients pelvis or tie their legs together which helps. Don’t rock the pelvis to check its stability. If you want to touch something, feel the greater trochanters to see if there is any pain.

If you think the patient has broken their femur the patient is likely to have lots of bleeding. Splinting the leg can help with this.

Gain IV access the biggest cannula you can in both antecubital fossae. Take bloods: FBC, U&E, LFT, Amylase, pregnancy test, group and save, clotting, lactate, venous blood gas. Your seniors will decide if these are all really needed, you can always throw the blood away before it hits the lab!

Don’t rush to give any IV fluids until your senior is present, as IV fluids can dilute clotting factors and make things worse. Blood is often best!

**Disability**

This is another chance to assess how awake the patient is. Assess their consciousness level using AVPU. Have a quick chat with them – are they confused? Do they know where they are?

Have a look for any head injuries.

Get a pain score and give some analgesia. Running IV paracetamol through is often a quick and easy way of improving pain and its in before the CD keys have even been found (yes I know its apparently no more effective than oral). Remember that reassuring patients is a very effective way of relieving pain.

**Exposure**

Exposure has a few components. The most important part of this is to make sure your patient isn’t cold; if you’re cold, your blood doesn’t clot as quickly. This is *really* important. You lose a lot of heat just by lying on a cold floor, try it. Pre-hospitally, cover the patient above and below. In hospital, we often strip the patient off to examine them, but why not be the one that covers them up to prevent loss of dignity, as well as loss of heat?

The next part of this is to think about doing a secondary survey and looking for further injuries. To do this properly, you need to get down to skin, expose a bit at a time and re-cover it up when you’ve done. Its not often practical to do this pre-hospitally, and even in hospital you often need imaging and time before this can be properly performed.

**Packaging and Transport**

If your patient is unconscious, you need to decide what position to put them in. In most of our patients we use the recovery position as a nice safe position. This moves the c-spine quite a lot. If there are enough of you, consider log rolling the patient instead, to minimise spinal movement.

If you’re pre-hospital, you then need to plan how your patient is going to get to definitive care and where they’re going to go. This decision is best made by the pre-hospital practitioners who fully understand all the nuances.
**Initial assessment and management**

Helicopter Transport: if you think the patient needs helicopter transport to hospital, you should have already dialled 999 and the operators make that decision.

Emergency Ambulance: an emergency ambulance is needed if the patient needs treatment en route to hospital, or wouldn’t manage to get in to a car.

Own Transport: If the patient doesn’t need an ambulance, they can make their own way to hospital for assessment. They do not need to arrive in the Emergency Department in an ambulance to get seen. It doesn’t get you assessed any quicker. If you think the patient has broken their arm, they don’t need an ambulance to get to hospital. If they have wounds that need suturing, they don’t need an ambulance to get to hospital. Chances are, your patient will be waiting over an hour for an ambulance by which time, they could have already made their way to the emergency department, been booked in and triaged.

If you’re in hospital, your seniors will help you decide whether the patient needs transporting elsewhere or not. Trauma care has all been centralised. Trauma units are local hospitals that can deal with most things and stabilise patients. Major Trauma Centres are bigger units that have all trauma specialties on site and can often provide more unified care for the multiply injured patient. Some patients will need transferring from your trauma unit to your major trauma centre. In London, our MTCs are centrally based which is great if you live inside the M25, but if you get transferred from Hastings to Kings, your journey home is quite long!

**Re-stock**

Normally for trauma we have used kit and equipment. We would now need to re-stock and clean any equipment used, don’t rely on anyone else doing it. We also need to think about whether we are still physically and emotionally prepared to continue at work, we may need a quick debrief.

If this has wet your appetite for more trauma care, have a look at all our trauma resources on RCEMLearning. We have podcasts, blogs, and e-learning. Your hospital is likely to run trauma simulation courses. ATLS is a great starter course for anyone wanting to learn trauma systems. Although much complained about, it still provides a basic, core common language for anyone involved in trauma care.

For those of you who like a podcast segment, have another listen to our segments on [NICE trauma imaging guidelines](#) and the use of CT in trauma.
Airway maintenance is a key skill of the trauma provider. There are airway skills specific to the trauma airway but if you consolidate the basics, that's a great start. We've got an e-learning module on it [here](#). If you want to refresh your knowledge and you're short of time, have a look at our open access [basic airway](#) and [advanced airway](#) reference guide. When you're ready with the basics, listen to the legend [John Hinds (RIP) airway lecture](#), and then consolidate your knowledge with this [SAQ](#).
Anaphylaxis causes about 20 deaths / year in the UK [3]. Severe sepsis is estimated to affect 0.3% of the US population / year with a mortality of 28.6% (equating to 215,000 deaths / year) [4]. Cardiogenic shock has an even higher mortality (50-90% [5]).

Definition

Unfortunately for our campaign to eliminate the word shock, and thus help to untangle the confusion between sepsis and trauma there is no other monosyllable that quite does the job. Still, we would be better off without the word, and our teaching would be clearer if we never used it, since such a departure would cause each surgeon or physician to specify causes and mechanisms rather than contenting himself with the diagnosis of shock, implying that all patients in such a state are essentially the same [6].

Figure 2:

Shock can be the result of numerous different pathophysiological processes that can be broadly accommodated within 4, somewhat artificial categories: hypovolaemic, distributive, obstructive and cardiogenic [8].

The relative incidence and mortality of shock varies greatly depending on the population and the cause. Worldwide the greatest number of deaths from shock probably occurs in under 5 year old children with hypovolaemia as a result of diarrhoeal illness: UNICEF estimate about 2 million / year [1]. By contrast the Office of National Statistics record about 25 deaths from diarrhoeal illness in the same age group in the UK in 2005 [2].

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Shock is a somewhat lazy shorthand to describe the state that results when circulatory insufficiency leads to inadequate tissue perfusion and thus delivery of oxygen to the tissues of the body [7] (figure 1).
Irrespective of the cause the inadequate delivery of oxygen to tissues results in a failure of aerobic metabolism leading to end organ dysfunction.

The situation becomes more confusing if examples of dysoxia are considered to be types of shock. Cyanide poisoning is a classic example wherein mitochondria are prevented from utilising oxygen. Such disease states are outside the remit of this module as the primary problem is not one of circulatory compromise.

**Shock** describes a pathophysiological state with many different causes NOT a specific diagnosis

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**Basic science and pathophysiology**

The pathophysiology underlying shock varies enormously from cause to cause. This section will focus on some basic underlying concepts.

What determines oxygen delivery (DO2)? [9]

Take a moment to think about the key factors that determine global oxygen delivery ie the amount of oxygen leaving the left ventricle every minute.

Global oxygen delivery is determined by cardiac output (CO) and arterial oxygen content (CaO2). CO is heart rate (HR) x stroke volume (SV). The vast majority of oxygen carried in the blood is bound to haemoglobin. Only a tiny proportion is in solution (measured by PaO2). So the main determinants of arterial oxygen content are oxygen saturation and haemoglobin concentration.

For practical purposes global oxygen delivery can be calculated as:

\[(\text{HR} \times \text{SV}) \times [\text{Hb}]_{\text{g/dl}} \times 10 \times 1.34 \times \text{sO}_2 \text{ml/l} \]

(The 10 is to convert g/dl of Hb to g/l. The 1.34 represents the amount of oxygen (in ml) carried by one gram of 100% saturated haemoglobin)

To put this into context imagine a man who has suffered multiple injuries in a road traffic accident. The table below shows the effect of 4 different interventions on oxygen delivery (each assumes that all other variables remain the same).

<table>
<thead>
<tr>
<th>Effect on oxygen delivery</th>
<th>Intervention</th>
<th>Increase in oxygen delivery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greatest</td>
<td>Increasing [Hb] from 6g/dl to 9g/dl</td>
<td>50%</td>
</tr>
<tr>
<td></td>
<td>Increasing cardiac output by 20% with crystalloid boluses</td>
<td>20%</td>
</tr>
<tr>
<td></td>
<td>Increasing oxygen saturation from 91% to 100% with supplemental oxygen</td>
<td>10%</td>
</tr>
<tr>
<td>Least</td>
<td>Increasing PaO2 from 12kPa to 40kPa with supplemental oxygen</td>
<td>&lt;1%</td>
</tr>
</tbody>
</table>
In this example increasing [Hb] is the single most effective intervention, followed by increasing cardiac output. Of course a blood transfusion would in reality achieve both. Ensuring oxygen saturation is maximal is somewhat effective while achieving supranormal PaO2 achieves little. The top 3 interventions together increase oxygen delivery by almost 100%.

In hypovolaemic, obstructive, cardiogenic shock and to a certain extent the later stages of septic shock, global oxygen delivery is the primary problem. In sepsis, anaphylaxis and neurogenic shock failure of oxygen delivery is a result of maldistribution of global oxygen delivery both between and within organs. Cardiac output may be normal, increased or reduced [10].

What happens when oxygen delivery is inadequate?

In very simple terms cells run on adenosine triphosphate (ATP). ATP is produced by respiration, either aerobic or anaerobic. Anaerobic respiration is about 18 times less efficient than aerobic. In the absence of adequate oxygen delivery cells run out of energy and cease to function effectively and, if the situation is not corrected, die. On the macroscopic level this is apparent in organ dysfunction and failure.

Compensation and decompensation

The body has a range of compensatory mechanisms to cope with a reduction in oxygen delivery as a result of circulatory compromise including the ability to dramatically increase the amount of oxygen extracted from the blood (the oxygen extraction ratio (OER)). The initial clinical signs and symptoms that suggest shock is developing are the result of the compensatory mechanisms, the later features are those of organ dysfunction as the compensatory mechanisms fail. If the causative pathology is not identified and corrected quickly enough the uncompensated shock state will progress to a situation of irreversible damage.

Learning Bite

There is a window of opportunity in which to identify and treat a shock state after which the damage will become irreversible.

Clinical assessment

Assessment and management of the patient must follow an ABCDE approach and involve 4 key steps that should ideally occur concurrently:

1. Recognition of the degree of physiological compromise
2. Identification of the cause
3. Correction of the physiological deficit
4. Treatment of the underlying cause

A focussed history must be obtained and examination performed concurrently with resuscitation. Some specific clinical findings merit further discussion:

Heart Rate

Why does heart rate increase in most types of shock? In what types of shock does the heart rate not increase?

Cardiac output (CO) is heart rate (HR) x stroke volume (SV). A reduction in CO causes reduced activity of arterial baroreceptors [11] causing increased sympathetic and reduced parasympathetic activity. Heart rate increases and cardiac output is restored towards normal. An increase in heart rate is an early sign of compensation but its absence does not exclude significant compromise. While the majority of patients with acute blood loss demonstrate the typical tachycardic response it is important to be aware that as many as 30-35% may present with an initial relative bradycardia (ie heart rate not in excess of 100 beats/min) [12]. This is in addition to patients on beta-blockers who are pharmacologically prevented from mounting a tachycardia and those in whom a tachycardia may go unrecognised as their normal resting heart rate is lower than average (i.e. athletes). Bradycardia may of course be the cause of the shock state (eg complete heart block, beta-blocker or calcium antagonist overdose).

Learning Bite

Absence of tachycardia does not rule out haemorrhagic shock.
Skin

How can examination of the skin aid the assessment of the degree of physiological compromise? What clues to the differential diagnosis may be available?

With a reduced Qt vasoconstriction caused by increased sympathetic activity will divert blood away from the peripheral circulation leading to cool peripheries. Capillary refill is a useful test in assessing dehydration in diarrhoeal illness in children [13] and has some value in paediatric trauma [14] but is of questionable value in adult patients [15]. Sweating as a result of increased sympathetic activity may produce clamminess (diaphoresis).

In distributive shock the skin may be warm and dry: neurogenic shock (loss of sympathetic tone as a result of cord injury) leads to vasodilatation and an absence of sweating. In UK trauma patients neurogenic shock occurs in about 20% of patients with cervical cord injuries (7% for thoracic, 3% for lumbar) at presentation [16].

Anaphylaxis is characterised by patchy or generalised erythema, urticaria and angioedema but skin or mucosal changes may be absent in up to 20% [17].

In early sepsis the skin may be warm but as the condition worsens peripheral perfusion is reduced. In children cool hands and feet are early findings in meningococcal sepsis [18] and the reversal of the proximal progression of cool skin gives some indication of the adequacy of resuscitation. The skin may provide clues as to the causative organism such as purpura in meningococcal infection and generalized erythema in toxic shock syndrome. A thorough examination is needed to identify possible occult sources.

Respiratory Rate

Respiratory rate is an excellent marker of physiological compromise that is poorly utilised and often overlooked [19]. Respiratory rate may be increased because of hypoxia (e.g. in pneumonia) but will often remain elevated despite correction of CaO2 as worsening perfusion generates a metabolic acidosis requiring respiratory compensation.

Learning Bite

Pay attention to the respiratory rate and never ignore tachypnoea

Blood Pressure

How useful is blood pressure as a marker of shock?

It is a common mistake to equate a normal blood pressure with the absence of shock. The body’s ability to compensate means blood pressure is maintained until a late stage in the progression from physiological insult to an irreversible shock state. This is demonstrated well by acute blood loss [20]:
Not until 30-40% of the circulating blood volume is lost does the blood pressure begin to fall. Note also a reduction in pulse pressure occurs before a reduction in systolic BP as the diastolic increases in response to vasoconstriction. The mean arterial pressure (MAP = (systolic + 2 x diastolic) / 3) is a better representation of organ perfusion than the systolic. A MAP of 65mmHg is considered to be sufficient for organ perfusion in a healthy adult.

Conscious level

Conscious level may be reduced for a host of reasons in the acutely unwell patient but it is vital to bear in mind that alterations in conscious level may be a result of inadequate cerebral perfusion. The combative drunk should only be assumed to be a combative drunk once other pathologies have been realistically excluded.

Urine output

Urine output is of little use in initial assessment but any patient who is shocked should be catheterised early (beware of urethral injury in trauma) to provide an indication of the adequacy of resuscitation over time. In some patients urine output may be misleading ie ongoing osmotic diuresis in a patient with diabetic ketoacidosis despite shock.

Other history and examination findings

The table below contains a number of possible clinical findings and their implication. It is, of course, by no means exhaustive but simply illustrates the importance of a thorough history and examination.
Learning Bite

Don’t be fooled by seemingly normal physiology that may be concealing significant compensated shock

Investigation Strategies

The majority of the investigations in a shocked patient will be focused on identifying the cause of the shock (e.g. FAST scan in trauma, ECG in cardiogenic shock, echocardiography in massive pulmonary embolus). It is well recognised in trauma that reliance on physiological parameters such as BP and urine output will lead to under-resuscitation in many patients [21] and the preceeding sections have highlighted that a falling blood pressure in particular is a late sign in shock. So what investigations could help identify compensated shock and help monitor response to treatment?

Blood lactate

Failing oxygen delivery leads to anaerobic respiration which generates lactate [22]. A lactate level of greater than 4 mmol/l is associated with increased ICU admission and mortality in normotensive patients with sepsis and those with higher lactate clearance at 6 hours have an improved outcome [23].
It is unclear whether or not lactate levels on admission are a useful predictor of outcome in trauma patients [24,25]. Normalisation of lactate with resuscitation does correlate with improved survival in trauma [26], surgical [27] and post cardiac arrest [28] patients but the timescale over which normalisation occurred in these studies (24-48 hours) makes the existing evidence less relevant to initial resuscitation in the ED setting.

**Learning Bite**

**Blood lactate is a useful marker of severity in shock states**

Base excess and bicarbonate levels offer some guidance to the degree of compromise and adequacy of resuscitation but can be normal in a proportion of patients with significantly abnormal lactate levels in sepsis [29]. Similarly anion gap has been shown to be a poor marker for lactic acidosis in the ED [30].

**Central venous oxygen saturation**

As mentioned earlier the oxygen content of any given quantity of blood can be calculated from the haemoglobin concentration and oxygen saturation. As oxygen is extracted from the blood the oxygen saturation falls. Consequently the oxygen saturation of blood returning to the lungs (ie blood from the pulmonary artery) can give an indication of total body oxygen extraction. Usually this mixed venous blood is around 70-75% saturated (SvO2)[10]. If it falls below this figure then oxygen extraction has had to increase. In shock states this is usually because oxygen delivery has become inadequate. Demand exceeds supply.

In ED practice sampling SvO2 is impractical. Consequently interest has focussed on the usefulness of central venous oxygen saturation (ScvO2) which tends to be about 5-7% higher. Rivers work on early goal directed therapy has incorporated ScvO2 as a guide for blood transfusion and inotropic support with a survival benefit and its use is also supported by the Surviving Sepsis Campaign. It should be noted however that in sepsis in particular ScvO2 can be misleading. As sepsis progresses oxygen extraction by the tissues becomes less and less efficient and the blood returning to the heart remains oxygenated. In this situation a normal or high ScvO2 can reflect a worsening clinical picture.

**Learning Bite**

**Don’t be falsely reassured by a normal ScvO2 it may simply represent the tissues inability to utilise oxygen**

![Fig 1. The situation in a healthy individual](image1)

Fig 1. The situation in a healthy individual

![Fig 2. The situation in a shock state where inadequate tissue perfusion has resulted in a reduction in usual oxygen delivery necessitating an increase in oxygen extraction. This is reflected in a fall in the central venous blood saturation.](image2)
Management

Once a shock state is recognised treatment must focus on:

1. Reversing the physiological deficit (resuscitation)
2. Treating the cause. Other blogs on RCEMLearning will provide much more detail on treatment of specific types of shock.

Frequent clinical reassessment following each intervention will give an indication of the patients response. The response will be rapid, transient or none. If the response is not satisfactory then consideration must be given to the adequacy of resuscitation so far, accuracy of the diagnosis, need for immediate definitive treatment (e.g. decompression of tension pneumothorax) and the need for more invasive cardiovascular monitoring.

Learning Bite

Planning and providing definitive treatment tailored to the specific diagnosis must accompany resuscitation

In general an aggressive early goal directed approach to maximise oxygen delivery is indicated as in sepsis [31,32] and early management of sick surgical patients although caution may need to be exercised in some situations (for example in penetrating chest trauma where normalisation of blood pressure with fluid resuscitation prior to surgical haemostasis may worsen outcome [33]). If presentation or recognition of the shock state occurs too late goal directed therapy may be counterproductive [34,35].

In the majority of cases the initial and critical element of therapy (together with high flow supplemental oxygen) will be fluid boluses. These should be small volumes (e.g 250ml) given quickly (i.e over 5 10 minutes) with reassessment after each. There is no evidence that ordinary crystalloid (normal saline or Hartmanns is inferior to colloid [36].

Given the key role of haemoglobin concentration in determining oxygen delivery it is important that it is maintained with judicious transfusion [31]. Excessive transfusion is unwise as it has been found to be of no benefit and possibly a risk in critically ill patients a reasonable target is around 7-9 g/dl in otherwise healthy patients [37,38].

Inotropes have a role in some conditions (e.g sepsis, cardiogenic shock, neurogenic shock, anaphylaxis) but are likely to be harmful in other settings (e.g when used in the inadequately resuscitated hypovolaemic patient). Exactly which inotrope in which setting is a subject of vigorous ongoing debate [39].

Consideration must be given to early intubation and ventilation in many shocked patients. Oxygen consumption can be dramatically reduced by taking over the work of breathing [10]. In septic patients increased capillary permeability may mean that necessary fluid resuscitation leads to pulmonary oedema a fact that is recognised more widely in the paediatric population where guidelines emphasise the need to consider intubation once fluid resuscitation exceeds 40-60 ml/kg [40].

Initial enthusiasm for low dose steroids in sepsis is now waning [41]. With the exception of adrenal insufficiency (Addisonian crisis) which should be considered in all hypotensive patients where there is no apparent cause, particularly those on corticosteroids and if there is both unexplained hyponatraemia and hyperkalaemia, there is no role for steroid use in the initial resuscitation and treatment of a shocked patient.

Key Learning Points

- Shock is a simplistic concept for a pathological state that can arise from a whole range of different disease processes. It is not a diagnosis in itself
- Shock can be subdivided into hypovolaemic, distributive, obstructive and cardiogenic causes.
- Global oxygen delivery is determined by cardiac output and arterial oxygen content, but perfusion of individual organs depends on many other factors.
- Initial compensatory responses can conceal the developing shock state from the clinician who
relies on simple measures such as blood pressure and heart rate.

- Failure to intervene promptly enough will allow progression to an irreversible state characterised by multi-organ failure. Grade of Recommendation D, level of evidence 5

- Blood lactate can be a useful adjunct to initial clinical assessment. Grade of Recommendation B, Level of Evidence 2b

- Resuscitation and definitive treatment should be contemporaneous and must be tailored to the specific diagnosis. Grade of Recommendation D, level evidence 5

- An increasing evidence base supports the role of early goal directed therapy in sepsis. Grade of Recommendation A, Level of Evidence 1a

**Safety pearls and Pitfalls**

1. Equating a normal systolic blood pressure with the absence of significant physiological compromise.
2. Assuming that a normal heart rate suggests minimal physiological derangement.
3. Interpreting a normal haemoglobin in acute haemorrhage as indicating minimal blood loss (haemodilution takes time or crystalloid resuscitation to develop).
4. Failure to spot relatively subtle abnormalities that can indicate significant illness such as a compensated metabolic acidosis.
5. Under resuscitation and lack of utilisation of markers such as lactate, ScvO2 and urine output to guide ongoing resuscitation.
6. Failure to predict need for intubation e.g. in septic patients requiring aggressive fluid resuscitation.
7. Failure to give antibiotics early in sepsis
8. Failure to pursue early goal directed therapy in sepsis (only 18.8% of UK EDs in 2007)
9. Failure to recognise atypical presentations (e.g. toxic shock syndrome, necrotising fasciitis, anaphylaxis with predominant abdominal symptoms)

Have a look at our module on shock, and a listen to our old but good blood loss podcast, and our making a difference podcast.

We also have a great blog on Managing Major Haemorrhage in the Emergency Department

**References**

10. Leach RF, Treacher DF. The pulmonary physician in critical care 2: Oxygen delivery and consumption in the critically ill. Thorax 2002;57;170-177
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THORACIC TRAUMA

Author: Gavin Lloyd / Editor: Jason M Kendall, Stewart McMorran / Codes: C3AP1a, HAP26 / Published: 08/05/2017 / Review Date: 08/05/2020
LIFE THREATENING

For each life-threatening thoracic injury this work will include:

A definition and context to include the incidence, likely mechanism of injury and (where appropriate) the likelihood of the injury being missed clinically and/or radiologically

Clinical assessment and identification of the injury

Treatment

Tension pneumothorax

Definition and context

Think expanding pneumothorax that increasingly limits ventilation and venous return perhaps a better concept for teaching purposes. It is not an on/off phenomenon, rather a continuum.

So even impressive expansion, (Fig 1) may be well tolerated in young individuals with no co-morbidities and no other injuries. In fact tolerated so well that you may miss the clinical diagnosis no harm done.

Given that the expansion is dynamic, be vigilant in patients with a chest x-ray proven small pneumothorax in whom you elect not to insert a chest drain.

Clinical assessment and identification

Symptoms and signs depend on where your patient is on the expanding pneumothorax continuum clinical features become more obvious with expansion.

(a) For awake patients:

Universal features of tension pneumothorax are chest pain and respiratory compromise [1], neither of which are discriminatory of course. Low oxygen saturations may be an early feature; hypotension tends to be late. Both may have other causes.

Lateralisng the pneumothorax may not be straightforward listen for decreased breath sounds on the affected side. Listen in the axillae rather than over the anterior chest wall.

Note the classical signs of hyper-resonance and tracheal deviation are soft and difficult to elicit.
For ventilated patients:

**Early reliable signs are:**

- Decrease in oxygen saturations this is likely to be prompt
- Decrease in BP
- Tachycardia

Look too for raised ventilation pressure (greater than 40) ensure that the ventilator pressure alarm settings are set appropriately (Fig 2). Lateralising signs are the same as for awake patients.

If your patient is not critical then there is time to get an urgent resus room CXR. This should help you:

- Confirm or refute the diagnosis
- Confirm the side of pneumothorax
- Rule in or out other diagnoses

**Learning Bite**

A portable CXR is recommended for tension pneumothorax, unless the patient is critical radiological evidence of tensioning does not necessarily correlate clinically

**Treatment**

Needle thoracocentesis is advocated for tension pneumothorax in the first instance in the ATLS manual [2]. Potential drawbacks to this strategy are:

- It tends to get over used, particularly in stable resus room patients in whom portable CXR is readily available and chest drain is the preferred treatment
- A lack of hiss (or bubbling, if you have put some saline in a syringe attached to the needle) might be considered as evidence of no tension pneumothorax the procedure doesn’t have 100% sensitivity
- A (4.5 cm) 14 gauge cannula may not reach the pleural space via the second intercostal space. In one study [3], this was the case in about a third of the patients. This might account for the point above
- The cannula can kink and cease to function
- A pneumothorax may be caused if the diagnosis is incorrect. This is of particular concern if the patient receives IPPV

In peri-arrest patients with suspected tension pneumothorax (particularly those with penetrating trauma) a thoracostomy (i.e. the initial part of a chest drain insertion) is probably the best option.

**Learning Bite**

Avoid needle thoracocentesis in peri-arrest patients with suspected tension pneumothorax thoracostomy is the better option

Chest drain insertion is covered in detail in a dedicated skills session [here](#). There are some selected key learning points from that session on the following page.
Thoracic Trauma

- The most common cause of serious injury (and death) as a result of chest drain insertion, is insertion at the incorrect site, usually too low

- Confirm that the drain lies within the chest wall cavity by looking for fogging of the tube and swinging of the chest drain with respiration

- Do not clamp the chest drain or apply suction

- The underwater seal needs to remain below the insertion site at all times

Pearls

- If you do perform needle thoracocentesis, have some saline in the syringe to demonstrate bubbling when the tension is hit

- Gross surgical emphysema in combination with pneumomediastinum (as per CXR) and a chest drain that continues to bubble, suggests tracheo-bronchial injury (Fig 3)

- If there is good clinical and radiological evidence of significant lateral chest wall injury, consider the second intercostal space anteriorly for the chest drain insertion its safer for the operator and less painful for the awake patient

Pitfalls

- One third of initial CXRs in trauma will not detect pneumothorax anaesthetic colleagues need to be aware of this if your patient leaves for theatre

- Cardiac tamponade may give similar signs clinically shock, with distended neck veins. A combination of your FAST skills, urgent CXR and consideration of the mechanism of injury should help you distinguish the two

- Beware other pathology masquerading as large (possibly tensioning?) pneumothorax on the CXR, for example an emphysematous bulla or gastrothorax (Figs 4 and 5). Reconsider the clinical presentation and consider CT where the CXR diagnosis remains in doubt

Fig 3: Tracheo-bronchial injury

Fig 4: Emphysematous bulla

Fig 5: Gastrothorax
Learning Bite

- A portable CXR is recommended for tension pneumothorax, unless the patient is critical, radiological evidence of tensioning does not necessarily correlate clinically.
- Avoid needle thoracocentesis in peri-arrest patients with suspected tension pneumothorax; thoracostomy is the better option.

Open pneumothorax

Definition and context

Think hole in the chest. It is also known as a communicating pneumothorax or sucking chest wound. Rarely, it is caused by ballistic (shot gun) injury. Clearly, this unlikely to be missed clinically. As the patient takes a breath in, the hole in the chest competes with the normal airway (mouth/nose to trachea) for delivery of air.

Learning Bite

A hole of only 1 or 2 cm in radius may cause serious respiratory compromise, particularly in patients with comorbidities, and/or other injuries.

Clinical assessment and identification

Prompt clinical inspection front and back; a small sucking chest wound is usually audible. Treatment

- Definitive treatment is surgical repair. The emergency physician must alleviate any respiratory embarrassment, exclude associated injuries and identify the need for timely thoracotomy or laparotomy.
- Cover the wound, if not already done so by the paramedics. Sheets of Jelonet will do. Specific chest seal devices (Ashermann or Bolin) exist (Fig 6). If the hole is too big for either of the above, then cover with a large opsite, make a small hole in the middle and place a chest seal device on top if available.

Massive haemothorax

Definition and context

A haemothorax with a volume greater than 1500 ml, or greater than one third of the patients blood volume. This is an uncommon injury which can be caused by blunt or penetrating trauma, and is unlikely to be missed radiologically. It creates a problem because of shock (haemorrhagic and impaired venous return from the vena cava) and decreased ventilation (the lung on that side gets compressed).

Clinical assessment and identification

Think of the concept of expanding haemothorax (another continuum!): the signs will be less reliable in moderate haemothorax. Listen at the lung bases (Fig 7). There should be clear signs of shock prompting you to rule out the diagnosis. Use CXR and FAST to guide you.
Fig 7: Lung bases

FAST signs: the absence of a mirror image of liver/ lung or spleen/ lung across the diaphragm suggests a haemothorax (Fig 8); alternatively free fluid in the abdomen alone should prompt you to reconsider the source of haemorrhage (Fig 9).

Fig 8: Haemothorax

Fig 9: Free fluid

Treatment

• Intravenous fluid resuscitation
• Appropriate use of blood and blood products
• Chest drain only if there is respiratory compromise
• Ideally connect the drain to a cell salvage/saver machine

(autotransfusion) (Fig 10). If a cell saver is not readily available then use the usual apparatus, but prime the underwater seal with saline not sterile water the saline/blood collection can still be run through a cell saver later

Fig 10: Cell salvage/saver machine

• Occasionally a massive haemothorax may be well tolerated, typically in young patients with a chest stabbing. Delaying chest drain insertion until reaching thoracic theatre, where cell salvage exists, is an option

• Whilst a guideline for thoracotomy exists (see table), have a low threshold for engaging thoracic surgeons early
**Thoracic Trauma**

- In cases of exsanguinating haemorrhage, clamp the chest drain and arrange immediate thoracotomy in theatre

<table>
<thead>
<tr>
<th>ATLS indications for thoracotomy [2]</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Prompt drainage of 1500 ml blood, or a third of the patient's circulating volume</td>
</tr>
<tr>
<td>• &gt;200 ml/hr blood loss for 2-4 hrs</td>
</tr>
<tr>
<td>• Continued need for blood transfusion</td>
</tr>
</tbody>
</table>

**Pitfall**

You may underestimate the size of the haemothorax on a supine CXR (Fig 11).

![Fig 11: Haemothorax](image)

**Learning Bite**

- In massive haemothorax, insert a chest drain only if there are signs of respiratory compromise
- Prime the underwater seal for the chest drain with saline not sterile water

**Cardiac tamponade**

**Definition and context**

Cardiac tamponade is a collection of fluid (blood in the context of trauma) in the pericardial sack causing haemodynamic compromise.

When faced with a penetrating injury to chest, back or upper abdomen, think tension pneumothorax, think massive haemothorax, and think cardiac tamponade. Exclude or confirm tamponade with a FAST scan.

Cardiac tamponade is not an on/off phenomenon (yet another continuum), though the progression to PEA cardiac arrest may be rapid. 50 to 200 ml of blood in the pericardial sac may be enough. Cardiac tamponade as a result of blunt injury is exceptionally rare in those patients reaching hospital alive.

**Clinical assessment and identification**

FAST has particularly high sensitivity (about 95% according to ATLS [2]).

Do note that there are drawbacks in detecting and interpreting the classical clinical signs:

- Neck veins may not be distended if the patient has haemorrhagic shock
- Hypotension (and a raised respiratory rate) may have other causes
- Muffled heart sounds unlikely to be heard in the ED!
Thoracic Trauma

Treatment

• Fluid resuscitation to increase pre-load

• If the patient is haemodynamically stable refer for urgent surgical exploration in theatre. Look for co-existing injuries (especially pneumothorax) on a portable CXR first

• Thoracotomy if the patient presents within 10 minutes of cardiac arrest

• Correctly performed pericardiocentesis is likely to fail because the blood within the pericardium is clotted. The procedure will also delay thoracotomy. We (the authors) advise against pericardiocentesis unless there is really no one capable of opening the chest. ATLS [2] advises pericardiocentesis only as a temporising measure, pending thoracotomy

Learning Bite

• Cardiac tamponade as a result of blunt injury is exceptionally rare

• FAST scanning is highly sensitive

• Thoracotomy, not pericardiocentesis is recommended

Flail chest

Definition and context

This occurs when a series of ribs (usually 3 or more) are fractured segmentally (i.e. in more than one place) resulting in a free or floating section of the chest wall. This injury is relatively common small flails may be missed clinically.

Learning Bite

• Beware underlying pulmonary contusions which are inevitable, and may cause significant morbidity and mortality in any age group

• Considerable force is required to create a flail chest in young people look carefully for other injuries, both intra and extra-thoracic

• Multiple rib fractures are a potential source of significant haemorrhage

Clinical assessment and identification

By palpation as well as inspection.

A CXR might identify associated pneumothorax, haemothorax and pulmonary contusions (Fig 12). The appearance of early pulmonary contusions is particularly worrying; evidence of further and perhaps extensive contusion (with physiological effect) may evolve.
Fig 12: Pulmonary contusions

Treatment

- Treatment options depend largely on the respiratory embarrassment caused: consider your patients clinical condition, the size of the flail chest, associated injuries, age, co-morbidities and destination from resus (theatre, CT scan, ITU or ward)

- For patients with major trauma (apply common sense in defining this) proceed to intubation and ventilation (IPPV). This enables you to take better control of respiratory compromise, addresses your patients pain (remember to give adequate morphine post RSI) and facilitates clinical procedures e.g. chest drain insertion and CT scan

- Insert a chest drain for associated pneumothorax and haemothorax. CT is likely to pick up occult pneumothoraces; whilst usually small, chest drain insertion is recommended if the treatment option is ventilation

- Judicious fluid resuscitation since excessive fluid floods injured lung tissue

- Definitive surgery (internal fixation of ribs) at the discretion of cardiothoracic surgeons

- Discuss treatment options with ICU and thoracic surgical colleagues for patients with a flail segment causing limited respiratory embarrassment, and in whom there are no other life-threatening injuries. A conservative approach might include the use of thoracic epidural, intercostal nerve blocks or patient controlled analgesia, and CPAP and physiotherapy

Pulmonary contusion

Definition and context

Bruised lung; unlikely to be missed radiologically unless the CXR is early.

Potentially life threatening since:

- The patient is at risk of hypoxaemia

- Because of the force involved to cause the injury, associated injuries are common

- Injured lung is vulnerable to flooding from aggressive fluid resuscitation

Patients with co-morbidities and/or advanced age are particularly at risk from this injury.

Clinical assessment and identification

- Look for patchy white areas progressing to frank consolidation on the CXR (aspiration and haemorrhage are differential diagnoses) (Fig 13)
Fig 13: Lung contusion

• Contusions visible on the initial CXR suggests significant injury, with further radiological changes and blood gas derangement likely to follow

• Look for associated rib fractures and haemo/pneumothorax

• Rib fractures do not always co-exist, particularly in the young (where their existence indicates that significant force created the injury)

Treatment

• IPPV with Positive End Expiratory Pressure (PEEP) for the sicker patients

• Judicious use of fluids, consider insertion of a central line and arterial line

• No evidence for steroids or prophylactic antibiotics

• Avoid colloids since these will breach injured lung tissue and worsen hypoxia

• Discuss disposition of each patient with ITU and thoracic surgical colleagues

Learning Bite

• Lung contusion is a marker of significant injury

• Early CXR evidence of contusion is particularly worrying

Myocardial contusion

Definition and context

Myocardial bruising caused by blunt injury, including deceleration and ballistic mechanisms. The key problem with interpreting the literature is the lack of a diagnostic gold standard (apart from post mortem).

Clinical assessment and identification

• A normal ECG effectively rules out the condition [4,5]
• Unexplained tachycardia may be a clue. Look too for atrial and ventricular ectopics.
• Consider bedside echocardiogram
• Consider troponin [6]
**Thoracic Trauma**

**Treatment**

There is no direct ED-based intervention to treat the myocardial contusion itself; treat the following if identified:

- Hypoxaemia
- Acidaemia
- Fluid status
- Low haemoglobin

Monitor ECG. Consider a central and arterial line.

**Pitfall**

Beware labelling ST changes as myocardial contusion; there may have been a primary cardiac event that precipitated the accident.

**Learning Bite**

A normal ECG effectively rules out myocardial contusion [2]

**Aortic injury**

**Definition and context**

Consider carefully in rapid deceleration injuries, e.g. road traffic accidents and falls. Missing the diagnosis both clinically and on CXR is quite common. The few patients (about 10%) who make it alive to the ED will have haemorrhage tamponaded by aortic adventitia (a vulnerable pseudo-aneurysm). There is no increased risk of injury related to atherosclerosis. It is young males who engage most in risk taking activities that end in rapid deceleration accidents (Fig 14).

![Fig 14: Rapid deceleration accident](image)

**Clinical assessment and identification**

Most patients will complain of other associated injuries rather than specific symptoms of aortic injury.

The majority of ruptures in patients reaching hospital alive are just distal of the left subclavian artery, so a difference in blood pressure between both arms is not necessarily a feature.

Occasional clinical clues include generalised hypertension, upper extremity hypertension in combination with weak or absent femoral pulses, and a harsh systolic murmur.

An erect good-quality CXR has good but not perfect sensitivity in ruling out the diagnosis in low risk patients [7]. Such a CXR is not achievable in most multi-trauma patients, Neither are these patients necessarily low risk.

**Several CXR features might suggest the injury according to ATLS [2]:**

- Widened mediastinum the most reliable sign
- Fractures of the first and second ribs
- Obliteration of the aortic knob
- Deviation of the trachea to the right
- Presence of a pleural cap
- Elevation and rightward shift of the right main stem bronchus
- Depression of the left main stem bronchus
- Obliteration of the space between the pulmonary artery and the aorta
- Deviation of the nasogastric tube to the right

Contrast CT thorax is the investigation of choice.

Aortic injury is one of many causes of mediastinal haematoma; sternal fracture and thoracic vertebral fracture are also associated with mediastinal haematomas (Fig 15).
Thoracic Trauma

Fig 15: Mediastinal haematoma

Treatment

Surgical repair or endovascular stenting, which may require transfer from your facility. Competing and likely overriding injuries include life-threatening head, abdominal or pelvic injuries.

Control hypertension (systolic no more than 110 mmHg) and tachycardia with appropriate analgesia; labetalol is the agent of choice to control acute hypertension in this setting.

Learning Bite

Young males are the most likely candidates for aortic injury

Diaphragmatic injury

Definition and context

Diaphragmatic injury is usually caused by penetrating rather than blunt injury. It is easily missed both clinically and radiologically.

In blunt injury it is three times more common on the left (the right hemi-diaphragm being protected by the liver) and nearly always at the weakest point, posterolaterally.

A diaphragmatic breach will not heal spontaneously because of the differential pressure gradients between chest and abdomen. Abdominal content herniation is a possibility and may be picked up years later.

Figs 16 and 17: Diaphragmatic injury
Clinical assessment and identification

Symptoms are likely to be masked by associated injuries.

Diaphragm injuries resulting from knives or bullets are more likely to be detected on surgical exploration.

In blunt injuries, particularly those causing an abrupt rise in intra-abdominal pressure, be careful not to interpret a gastrothorax (Fig 18) for a large pneumothorax; both will cause respiratory embarrassment.

Learning Bite

- Examine the CT carefully in patients who have sustained a (blunt) abrupt increase in intra-abdominal pressure
- Diaphragmatic injury needs excluding by surgical colleagues in cases of penetrating injury requiring theatre

Oesophageal injury

This rare injury is often initially missed both clinically and radiologically.

Other associated injuries will normally predominate the clinical presentation e.g. a neck stabbing with tracheal and vascular disruption.

Operative repair or endoluminal stenting should be considered in the context of other associated injuries.

Tracheal/bronchial injury

Definition and context

This rare injury is typically caused by significant deceleration injuries; most patients die at the scene of the accident. It is unlikely to be missed clinically or radiologically in survivors, since clinical effects are usually dramatic.

Clinical assessment and identification

A massive air leak is suggested by gross surgical emphysema, pneumomediastinum and a vigorously bubbling chest drain that has failed to alleviate respiratory compromise.

Haemoptysis is an additional clue

Treatment

Discuss intubation strategy with senior anaesthetic colleagues (consider single or double cuffed tubes, use of fibre optics, etc).

Consider additional large bore chest drain on the affected side (one intercostal space further up). Do not attach suction to the chest drain.
Other significant patient injuries may influence your resuscitation strategy.

**Learning Bite**

Two large bore chest drains may be needed to counter the air leak of a tracheo-bronchial injury

**Simple pneumothorax**

This is a common injury which is readily missed on CXR and subsequently discovered on CT.

Small, asymptomatic/occult pneumothoraces may be observed, even if the patient is ventilated [8]. About a third may deteriorate clinically, necessitating a drain.

No guideline regarding the safe timing for flying following a simple traumatic pneumothorax exists. A pragmatic approach may be to adopt British Thoracic Society guidelines for spontaneous pneumothorax: flying is permissible, once chest x-ray confirms resolution of the pneumothorax.

**Rib fractures**

Significant force is required to break ribs in the young; underlying injury is typical, especially lung contusions. Whilst less force is required in the elderly, even an isolated rib fracture can result in significant morbidity (e.g. secondary pneumonia) particularly in those with pre-existing comorbidities. In addition to standard therapy consider the role of patient-controlled analgesia, thoracic epidural and physiotherapy for vulnerable patients.

**Sternal fractures**

These are relatively benign injuries but may be associated with underlying myocardial or pulmonary contusion. Consider the role of patient-controlled analgesia or local anaesthetic via a sternal catheter [9] in vulnerable patients.

**Posterior sternoclavicular joint dislocation**

This an exceptionally rare injury. It is clinically important since the medial clavicular head may compromise the airway or major vessels.

If there is evidence of compromise, reduction of the dislocation should be attempted. Abduct the arm to 90 and extend 10-15 and apply traction (with counter attraction to the torso from another colleague); maintain traction and pull the medial end of the clavicle forward with your fingers and thumb. If this fails, prepare the skin with iodine and local anaesthetic and repeat with a towel clip [10].

**Fig 19: Simple pneumothorax**

**Fig 20: Sternal fracture**
Key Learning Points

- A portable CXR is recommended for tension pneumothorax, unless the patient is critical radiological evidence of tensioning does not necessarily correlate clinically (Grade D, level 5)
- Avoid needle thoracocentesis in peri-arrest patients with suspected tension pneumothorax thoracostomy is the better option. (Grade D, Level 5)
- The most common cause of serious injury (and death) as a result of chest drain insertion, is insertion at the incorrect site, usually too low (Grade D, Level 5)
- Confirm that the drain lies within the chest wall cavity by looking for a fogging of the tube and swinging of the chest drain on respiration (Grade D, Level 5)
- A hole of only 1 or 2cm in radius may cause serious respiratory compromise, particularly in patients with comorbidities, and/or other injuries (Grade C, Level 4)
- Prime the underwater seal for the chest drain with saline not sterile water for suspected massive haemothorax (Grade D, Level 5)
- Cardiac tamponade as a result of blunt injury is exceptionally rare (Grade C, Level 4)
- FAST is highly sensitive in detecting blood in the pericardium (Grade C, Level 4)
- Thoracotomy, not pericardiocentesis is recommended for cardiac tamponade (Grade D, Level 5)
- Pulmonary contusions are near inevitable in patients with a flail chest, and may cause significant morbidity and mortality in any age group (Grade C, Level 4)
- Lung contusion is a marker of significant injury (Grade C, Level 4)
- Early CXR evidence of pulmonary contusion is particularly worrying (Grade C, Level 4)
- Multiple rib fractures are a potential source of significant haemorrhage (Grade C, Level 4)
- A haemothorax visible on chest x-ray requires a large bore chest drain (Grade D, Level 5)
- A normal ECG effectively rules out myocardial contusion (Grade C, Level 4)
- Young males are the most likely candidates for aortic injury (Grade C, Level 4)
- Examine the CT carefully in patients who have sustained an abrupt increase in intra-abdominal pressure (Grade D, Level 5)
- Diaphragmatic injury needs excluding by your surgical colleagues in cases of penetrating injury requiring theatre (Grade D, Level 5)
- Two large bore chest drains may be needed to counter the air leak of a tracheo-bronchial injury (Grade D, Level 5)

Chest trauma is increasingly evolving. If you’re not sure on your anatomy, pop over to emergencymedicineireland for a clinically relevent reminder. Then, have a look at our podcast from the London Trauma Conference, and our e-learning module.

References

ABDOMINAL AND PELVIC TRAUMA
It is a good idea to be familiar with the trauma services available in your hospital. The imaging services, radiological interventions and surgical capabilities will vary between a regional trauma centre and a district general hospital. If you are working in a department where the most appropriate services are not available on site, it is crucial to start thinking early about how best to access those required.

Prerequisites

Before commencing this session you should have:

- A good knowledge of the anatomy of the abdomen and the organ systems contained within

- An understanding of the physiology of hypovolaemia and shock, and the body’s response to pain and injury

Context

The assessment of abdominal trauma is notoriously difficult.

Serious intra-abdominal injuries may initially appear to be innocuous and localisation of symptoms is variable. A high index of suspicion is constantly required to recognise occult injury. The presence of associated injuries, such as head injury with altered conscious level, spinal injury with neurological sequelae or adjacent chest or pelvic injuries, further complicates clinical evaluation.

To aid initial diagnosis, investigation and management, abdominal trauma can be broadly grouped into penetrating or blunt, depending on the mechanism of injury.

DIRECT INJURY

This session will give you a plan for the initial assessment and management of abdominal trauma. It should enable you to think ahead and try to predict what underlying intra-abdominal injuries a patient may have sustained.
Learning Bite

Unrecognised abdominal injury remains a significant cause of death. Death may be prevented if intervention occurs early.

Penetrating Trauma

In penetrating trauma, the injuries sustained are caused by direct injury as the penetrating item passes through the organs and tissues in its path.

In the UK, this is most commonly knife-related injury. The site of entry, direction of the injury and the size and nature of the penetrating item will all provide information regarding the underlying injuries. The visible wound may be small and insignificant in appearance.

Learning Bite

It is impossible to tell from the appearance of a surface wound, the extent of underlying damage.

Wound Assessment

Caution is required in assessment of penetrating abdominal wounds. Patients with penetrating injury, even with normal vital signs, should be assessed by a senior surgeon. Unless the injury is trivial, all patients should be admitted to hospital for observation even if no further investigation is initially required.

Do not remove any object remaining in the wound, such as a knife, as this may be tamponading underlying vessels.

Learning Bite

In a physiologically normal patient without signs of peritonism, wound exploration should only be undertaken by an experienced surgeon, ideally in theatre.

Common Sites of Injury

Approximately 50% of penetrating abdominal injuries damage intraperitoneal structures. The peritoneal cavity is not breached in 25% of cases. Common sites of injury include the small bowel, colon and liver. Injuries to the buttock region are often associated with injury to pelvic vessels or rectal perforation, although intraperitoneal injury is rare.

Blunt Trauma

Blunt abdominal trauma commonly results from either a compression force or a deceleration injury. It has greater mortality than penetrating as there is often injury to multiple organ systems.

There are a number of classical injury patterns, which occur following common mechanisms of injury such as rapid deceleration while wearing a lap-only seat belt, or after direct impact with a car steering wheel. Recognition and understanding of these patterns will aid subsequent assessment.

The spleen and liver are the most commonly injured intraperitoneal organs in blunt trauma. Injury to intraperitoneal structures should be considered when evaluating any injury which occurs between the nipple line and the pelvis.
Basic Science and Anatomy

Abdominal Contents

Detailed anatomical knowledge of the abdomen is central in enabling the clinician to systematically assess patients with abdominal trauma and predict likely sites of injury. The abdominal contents can be divided into:

- The intra-abdominal structures
- Retroperitoneal structures
- The pelvic structures

Learning Bite

Detailed anatomical knowledge will enable an accurate appreciation of likely organ damage

Image: The layout of the intra-abdominal contents
Abdominal and Pelvic Trauma

Image: The retroperitoneum and the structures contained within it

Image: The great vessels of the abdomen and pelvis
Abdominal Anatomy

Injury to any region of the abdomen can of course create injury to any of the organs contained therein. However, commonly injury to a specific area will result in injury to those organs contained within that locality.

<table>
<thead>
<tr>
<th>Region</th>
<th>Organs potentially injured</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower chest</td>
<td>Liver, spleen, diaphragm, stomach</td>
</tr>
<tr>
<td>Anterior abdomen</td>
<td>Liver, spleen, colon, bladder, stomach, pancreas, transverse colon, ileum, jejunum</td>
</tr>
<tr>
<td>Flank</td>
<td>Kidneys, ureters, ascending and descending colon</td>
</tr>
<tr>
<td>Posterior abdomen</td>
<td>Great vessels, duodenum, pancreas, spinal cord</td>
</tr>
</tbody>
</table>

Image: Organs of the lower chest (mid to lower thoracic cage) 15% of stab wounds to this area are associated with significant visceral damage

Image: Organs of the anterior abdomen (between anterior axillary lines) 60% of injuries to this region penetrate the peritoneum and, of these, 4050% cause visceral damage
Abdominal and Pelvic Trauma

Image: Organs of the flank (between anterior and posterior axillary lines)

Injury Signs and Symptoms

Symptoms and signs are normally related to blood loss from injury to these very vascular organs. Signs of shock may be present but will be a late sign in a young, fit patient.

Injury to the liver or spleen are common injuries following blunt trauma and can be identified on a trauma CT scan.

Image: Signs and symptoms of a patient in hypovolaemic shock

Liver

Liver injuries account for 15-20% of intra-abdominal organ injuries but up to 50% of mortality, and 45% have associated splenic injury.

Conservative management is appropriate in 80% of cases, with surgical intervention reserved for ongoing and uncontrolled bleeding.

If hepatic or splenic injuries are detected on CT, the source of any ongoing bleeding can be detected through angiography. Through interventional radiology it can be possible to embolise the bleeding vessel and remove the need for surgical intervention.

Image: CT scan showing laceration to the liver

Spleen

Splenic injury is graded according to CT findings and treatment is guided by grade:

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade 1</td>
<td>Minor subcapsular tear or haematoma</td>
</tr>
<tr>
<td>Grade 2</td>
<td>Parenchymal injury not extending to the hilum</td>
</tr>
<tr>
<td>Grade 3</td>
<td>Major parenchymal injury involving vessels and hilum</td>
</tr>
<tr>
<td>Grade 4</td>
<td>Shattered spleen</td>
</tr>
</tbody>
</table>
Abdominal and Pelvic Trauma

The spleen contains approximately one unit of blood at any time.

Grade 1 or 2 injuries can usually be managed conservatively.

Image: CT scan showing ruptured spleen

Pancreas

- Injury to the pancreas may cause pancreatitis, which may develop over days.

- Blunt pancreatic injury may not be immediately recognised. It is relatively uncommon, occurring in around 10% of blunt abdominal injuries but it is rarely an isolated injury due to the position of the pancreas.

- Amylase elevation will often not occur until 3-4 hours after injury, if at all, and lipase is no more specific for pancreatic trauma.

Other Organs

The hollow organs, vascular structures and genito-urinary (GU) tract can also be injured and will each display their own characteristic responses to injury.

Image: Onset of peritonitis

Hollow viscus

- Peritoneal contamination with bowel contents will produce peritonism.

- There may be accompanying blood loss but the degree of hypovolaemia is generally less significant than in solid organ injury.

- Damage to the retroperitoneal portion of the bowel will not produce classical signs of peritonism as the leak will be contained.

Vascular structures

- Catastrophic blood loss may occur with injury to any of the large vessels in the abdomen.

- Aortic injury is usually fatal, but may be tamponaded if it occurs retroperitoneally.

- Injury to the inferior vena cava is likely to be associated with more insidious blood loss unless there is a large tear.
GU tract

- Bruising, haematuria or meatal blood are often the only signs of a GU injury.
- Injury to the intraperitoneal portion of the bladder may result in chemical peritonitis.

Clinical assessment

As with all trauma management, the priority is to identify immediately life-threatening injuries. Early airway protection, ventilatory support and circulatory resuscitation are paramount. An accurate history, if possible, will guide subsequent management. You may be reliant on the testimony of eyewitnesses or the ambulance service.

Clinical examination can be unreliable and falsely reassuring in the multiply injured patient. A significant mechanism and injury to adjacent body cavities should be taken seriously and prompt a thorough search for abdominal trauma.

Analgesia

Patients with abdominal trauma may require significant resuscitation and analgesia prior to formal abdominal assessment. In all cases where there is suspicion of abdominal trauma and blood loss, an urgent cross-match sample must be sent.

In haemorrhagic shock, the priority is resuscitation to restore adequate tissue perfusion and oxygen delivery. Adequate intravenous analgesia should be administered promptly and not delayed whilst investigations are obtained.

Learning Bite

A patient should always receive adequate intravenous opioid analgesia titrated to clinical response.

Image: Fluid replacement therapy and analgesia for the patient in hypovolaemic shock

Normal saline is the recommended initial intravenous resuscitation fluid. High flow oxygen and blood products, if appropriate, will maximise the oxygen-carrying potential of the intravascular fluid.

Management of haemorrhagic shock involves restoration and maintenance of circulating volume and tissue perfusion until bleeding is controlled. A patient who is GCS 15 and physiologically normal can be viewed as being adequately...
Abdominal and Pelvic Trauma

resuscitated, although frequent reassessment of this state is required. A patient who is initially haemodynamically normal and has no sign of significant abdominal injury can be treated in an observant fashion.

The table below shows the grades of hypovolaemic shock.

<table>
<thead>
<tr>
<th></th>
<th>Grade I</th>
<th>Grade II</th>
<th>Grade III</th>
<th>Grade IV</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Blood loss</strong></td>
<td>&lt;750ml</td>
<td>750-1500ml</td>
<td>1500-2000ml</td>
<td>&gt;2000ml</td>
</tr>
<tr>
<td><strong>Pulse</strong></td>
<td>normal</td>
<td>tachy</td>
<td>tachy</td>
<td>weak</td>
</tr>
<tr>
<td><strong>Blood pressure</strong></td>
<td>normal</td>
<td>raised diastolic</td>
<td>lowered systolic</td>
<td>very low</td>
</tr>
<tr>
<td><strong>Mental state</strong></td>
<td>normal</td>
<td>agitated</td>
<td>confused</td>
<td>obtundated</td>
</tr>
<tr>
<td><strong>Urine output</strong></td>
<td>30ml/h</td>
<td>2030ml/h</td>
<td>515ml/h</td>
<td>&lt;5 ml/h</td>
</tr>
<tr>
<td><strong>Respiratory rate</strong></td>
<td>normal</td>
<td>normal</td>
<td>tachypnoeic</td>
<td>tachypnoeic</td>
</tr>
</tbody>
</table>

**Fluid Resuscitation**

Aggressive fluid resuscitation without adequate haemostasis has been demonstrated to dilute clotting factors and potentially dislodge clots. Maintaining a normal blood pressure may worsen bleeding. If there is ongoing and brisk bleeding, it may be impossible to adequately resuscitate a patient until the tap is switched off. Examples of this situation would be a significant liver and spleen injury, or injury to one of the large intra-abdominal vessels. Continued fluid administration in this setting will eventually serve to haemodilute and impair coagulation. Immediate CT should be carried out and transfer from there to the angiographic suite if available or operating theatre depending on findings.

**Clinical Examination**

Clinical examination of the abdomen should always be undertaken as part of the primary survey. A conscious patient may complain of abdominal pain but in other cases, a patient with a distracting injury may less aware of their abdominal injury. Examination findings may be minimal even in significant injury and an index of suspicion must be maintained.

**Inspection** of the injured abdomen may show evidence of bruising, abrasions or penetrating trauma. Abdominal distension is suggestive of intra-abdominal haemorrhage and in association with signs of hypovolaemia must be dealt with promptly.
Abdominal and Pelvic Trauma

Palpation of the abdomen should be carried out and patient response documented. It is of particular importance to palpate the renal angles and examine the external genitalia.

Tenderness or guarding in any region must be noted and further investigated, but a multiply injured patient may not report much tenderness to palpation even with underlying injury.

A rigid abdomen is due to leak of bowel contents into the peritoneum from a hollow viscus injury.

Blood is by itself not a peritoneal irritant and, in a patient who has undergone a significant injury, serial examinations may demonstrate a gradually distending abdomen with little initial discomfort.

Rectal examination is useful if it demonstrates bleeding or a high-riding prostate suggestive of a pelvic injury and involvement of the genitourinary tract. Anal tone and sensation should be tested however, you should be aware though that in a head or spinally injured patient these will not be appreciated and cannot be used to exclude a pelvic or neurological injury.

Top-to-toe examination including a log-roll is imperative to ensure there are no other injuries. Whilst it is vital to fully expose the patient to adequately visualise all areas, attention should be paid to temperature control. Hypothermia in trauma patients is associated with significant mortality.

Learning Bite

Remember that an unconscious or spinal-injured patient will not be able to feel or localise abdominal tenderness

Management

A definitive patient management plan should be formulated as early as possible, including early consultation by relevant speciality teams. This may include surgeons, radiologists, anaesthetists, theatre staff, critical care and transfer teams if definitive care is not available in your hospital.

In a trauma centre, early trauma CT should be carried out, ideally once the patient has been haemodynamically stabilised through fluid resuscitation. If a patient remains unstable despite resuscitation then senior members of the trauma team (emergency, surgical and anaesthetics) should make a team decision weighing up the merits of CT versus immediate theatre.

In a DGH, contacting radiology to arrange imaging and thinking about arranging transfer to a trauma centre should be done as early as possible.

Trauma

Patients with suspected abdominal injuries from trauma can be roughly categorised into three groups:

• Those requiring immediate surgery due to catastrophic haemorrhage unresponsive to resuscitation

• Those requiring urgent investigation using appropriate diagnostic tests to determine intra-abdominal injury and decide the most appropriate management

• Those with no abdominal injury on clinical examination and where there is a low index of suspicion who require observation and sequential re-examination.
Abdominal and Pelvic Trauma

Patients who are physiologically normal and who have no indication for immediate imaging or intervention should be discussed early with the surgical team. A decision can then be made regarding the appropriate location for further observation.

Safety pearls and Pitfalls

• The presence of a physiologically normal patient does not exclude significant intra-abdominal injury
• Intoxication, head injury or distracting injuries may make clinical assessment of the abdomen unreliable
• An unconscious, anaesthetised or spinally-injured patient will not display signs of guarding
• Flank injuries may produce retroperitoneal injury to the kidneys or bowel without any initial symptoms. Damage to this area should prompt a search for such injuries
• Intraperitoneal blood will not produce signs of peritonitis
• A high-risk mechanism of injury dictates that a patient should be admitted and re-examined over several hours
• Always expose and inspect the entire patient. Just because you have found one stab wound doesn't mean there's not another one
• Beware of penetrating buttock injuries
• If there is an implement still in situ, leave it alone

Key Learning Points

• Abdominal trauma is an important but often preventable cause of mortality
• Early recognition and initiation of appropriate treatment is crucial with early fluid and blood product resuscitation being crucial.
• Consider that all trauma patients have intra-abdominal injury until proven otherwise
• Be alert to clues from the paramedics. A significant mechanism of injury should prompt an early and thorough search for injury, by trauma CT if possible.
• If interventional radiology is available, alert them early to the possibility of detection on CT of an injury amenable to repair to minimise delays.
• A trauma team approach is often best, with involvement of surgery, orthopaedics and anesthetics from the outset to minimise delays in decision making.
• Adequate resuscitation and frequent reassessment are vital, but definitive surgical intervention may be required. Involve the surgical team early
• Start thinking ahead. If your patient is likely to need an operation, alert the appropriate personnel as soon as possible
• Be aware of the radiological and surgical services available in your department. Immediate management in a trauma centre and a DGH may vary significantly

The abdomen is complicated, and you'd be forgiven for having forgotten your medical school anatomy. EM Ireland is here to help, and then consolidate your knowledge with our e-learning module, and a podcast.

We also have an excellent blog on Pelvic Fractures – A guide to treatment within a Trauma Unit for more information.
References


MAXFAX TRAUMA

Authors: Neel Bhandari / Codes: C3AP1D, CMP3, HMP3
In my experience, facial fractures can bleed and bleed and bleed. Trying to secure the airway can be an anaesthetist's nightmare. Here's why:

1. It's 2 am, they are in an unfamiliar environment (resus) and are often relatively junior!

2. Significant bleeding (and I mean significant!) from Le Fort and mandibular fractures can obstruct the airway. The blood supply to the face comes from the sphenopalantine and greater palatine arteries (branches of the external carotid artery) as well as carotid artery (that supplies the nasal cavity). That's a lot of arteries leading to a lot of bleeding!

3. The loss of normal facial bone structure coupled with the fact that you will have two suction tubes into the mouth in an attempt to clear the blood, will make bag-mask ventilation difficult. (You need two-person technique!)

4. There will likely be oedema to the soft palate from the mid facial fractures. The patient may also have a traumatic brain injury rendering him unable to self maintain his damaged airway.

My advice is to get your difficult airway trolley into the resus bay.

**PREPARATION**

You put an adult trauma call out and start preparing for the patient. You feel a bit like you have taken the blow yourself, but preparation is key, so get ready.

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My advice is to get your difficult airway trolley into the resus bay.
OK, your trauma team is present and the patient is wheeled in. If he is awake and you are not concerned over a cervical spine injury, sit him **upright and forward to allow for postural drainage of the torrential blood flow**. Keep him like that until the induction drugs go in, then lie him flat.

What if you are concerned about his C-spine? He comes in supine, with three point immobilisation of his cervical spine. There is a lot of blood. His airway is obstructing.

What can you do? Can or should you sit him upright and risk worsening any potential C-spine injury? If you don’t do something his airway will obstruct.

Take the blocks and tape off and turn him to a **left lateral position**. This still maintains some immobilisation and also allows for drainage of blood. Get two suction units and remove the rigid yankeur from the end and just use the tubing itself to control the bleeding if it is torrential.

### Fracture Assessment

How can you diagnose, by examination only, if the patient has a Le Fort fracture and which one he has?

**Stand on the patients right hand side. Place your left hand on his forehead to stabilise it. With your right hand, hold the upper teeth and anterior maxilla and gently rock the hard palate.**

**Le Fort I:**

It's a transverse fracture of the maxilla at the level of the nasal fossa. There is separation of the body of the maxilla from the pterygoid plate and nasal septum. Only the teeth and hard palate move.

**Le Fort II:**

It's a pyramidal fracture through the central maxilla and hard palate. The hard palate and nose move, but not the eyes.

**Le Fort III:**

There is craniofacial dysjunction. The entire face is separated from the skull. The fracture line runs through the frontozygomatic suture line, the orbit and base of the nose and ethmoids. The whole face moves.

**Le Fort IV:**

Is a Le Fort III along with a fracture to the frontal bone. Radiopaedia have an excellent blog on the different classifications with great 3D pictures which I really suggest you read.

**In Short:**

Le Fort I is a floating palate, Le Fort II is a floating maxilla and Le Fort III is a floating face! In all cases, you can help stop the bleeding by also grabbing the upper incisors and pulling the mid face forward as a temporising measure to disimpact the maxilla.

Back to the case in question: you have now diagnosed the patient with a Le Fort III and it is continuing to bleed.

### Airway Management

You need to secure the airway. When I was an ED registrar, chaotic scenes like this, often led to chaotic intubations. I have since learnt a valuable lesson (thanks to a paramedic friend of mine):

**“Neel! lets take 10 seconds for 10 minutes”**

Those few words have saved me so many times. Take 10 seconds to gather your team and explain what is about to happen. It will save you 10 minutes of messing around later! Your job is to bring order to chaos!
For instance in this situation you could:

1. Allocate roles (have a very low threshold to phone the boss on this case).

2. Set a target oxygen saturation level, that if the patient desaturates to below this you are going to tell whoever is intubating to pull out and ventilate again.

3. Mark on the neck where the cricothyroid membrane is, just incase you get into a can’t intubate, can’t ventilate situation (CICV). Have the surgical airway kit out and open. Read this for revision.

4. Go through the RSI checklist. Have the DAS failed intubation algorithm to hand. Listen to HEFT EM Cast for a refresher!

5. I would have the IGEL or LMA out of the packet ready to insert if needed. Remember Igel size +3 = size of ETT that can be passed through Igel. Realistically if you’re using a size 4 Igel, a size 7 ETT is too tight. Go for a size 6 ETT- bearing in mind you would need a size 10Ch Bougie not the normal 15Ch one!

6. Get two suction units ready and remove the rigid yankeurs (they tend to get blocked with clots too easily otherwise) and check there is enough battery power in them.

7. Get your video laryngoscope ready before the RSI (if you are lucky enough have one).

8. Induce the patient in the left lateral position or sat up right (if no concerns about the cervical spine). Only lay them flat when you are ready to insert the laryngoscope (you can intubate in the left lateral position but it is more difficult.) Now there are various options on how to intubate this patient. They depend on the time of day, what available staff there are (eg ENT) and what available kit you have. The options I can think of are:

1. RSI with direct laryngoscopy
2. Awake tracheostomy
3. Awake fiberoptic intubation
4. Awake direct laryngoscopy with intubation.

LIFTL has a great post on the pros and cons of each.

Lets say the patient is hypotensive and becoming more unconscious, you’ve put out a code red and are pre-loading him with blood. I would use a reduced dose of fentanyl (1mcg/kg) with ketamine (1-2mg/kg- as it gives sedation and preserves the respiratory drive) and rocuronium (1.5mg/kg). I appreciate there may be some arguments about that. Im not a fan of propofol especially in the unstable trauma patient!

Phew! It all went according to plan and the patient is now intubated! Before you start high-fiving everyone, you need to think about how to control the bleeding.

Controlling the bleeding

It just so happens that your trauma unit has a max fax theatre, which is used once a week for local elective cases. You need to get a pair of epistats and some bite blocks and a semi rigid cervical collar.

An Epistat (bottom left picture / next page) is a nasal catheter which has an anterior and posterior balloon. They are inserted in the same way as a nasopharyngeal airway, along the floor of the nose. The posterior balloon holds 10mls of saline and the anterior balloon holds up to 30 mls. The key to success is inserting an epistat into each nostril first before inflating the balloons. Then simultaneously inject the balloons with saline (using two people is easier than one person using both of their hands).
The overall aim is to create a rigid vertical structure:

• The mandible is stabilised on top of the semi-rigid cervical collar.
• The hard palate is held in place against the stable mandible by the bite blocks (top right picture). The maxilla is fixed in position by the epistats.

There are various accounts on which order this happens. I have always been taught that after the patient has been intubated:

1. Insert the epistats, like a nasopharyngeal airway, along the floor of the nose. Don't inflate the balloons yet.
2. Insert the bite blocks either side of the ETT. There is a groove on them that the ETT should sit next to.
3. Apply the C-spine collar. (Remember it has been undone for the RSI).
4. Inject 10 mls of saline to the posterior balloon (white port) of each epistat simultaneously, otherwise you risk disruption of the fractures.
5. Inject up to 30 mls of saline to the anterior port of each epistat (usually green) again simultaneously. I would do this 10 mls at a time until haemorrhage control is achieved.

Now you have done all you can to stabilise the patient and transfer on for a CT scan or to the nearest MTC. Your can finally give yourself that deserved high five.

Key learning points are:

1. Maxfax injuries can have torrential bleeding. Preparation for the intubation is key. Keep the patient upright if they are conscious or in a left lateral position to allow postural drainage.
2. Team work and good leadership are important. Take time if you need to enable yourself to take control of the case and reset everyone before the intubation, so they are all on the same page as you.
3. Know how to pack the face after the intubation. Remember to inflate the balloons of the epistat simultaneously only at the end.

The management of head trauma is ever evolving, and there's much debate over the appropriate management. Listen to this or this to start thinking about the debate, and finish off with this segment, looking at the most recent decision rule. When your scans come back as normal, listen about concussion here.

If you're confused about the GCS, wander away from RCEMLearning, to read all about its background and use.

References:

• UK HEMS SOP on max fax bleeding
• Radiopaedia: Le Fort Classification
• Life in the Fast Lane: Surgical Cricothyroidotomy
• Life in the Fast Lane: Airway in Facial Trauma
• Difficult Airway Society Guidelines 2015

Now you've learnt everything, time to consolidate your knowledge with a quick Clinical Case.
Assessing c-spines always used to fill me with dread, as I didn’t know what system to use, and I felt any missed injury would be significant. I still have a low threshold for imaging, but there are some patients, who just don’t need imaging – and there’s evidence to back it up. When I was an FY2 (a fair few year ago), one of my registrars said “Charlotte, to clear c-spines, you just need to have really big hairy balls”. And that is a sentiment that has still stuck with me, when clearing c-spines in the conscious patient!

The actual incidence of c-spine injury in blunt trauma victims is 2-12%, with less than 1% in walking, neurologically intact patients. C-spine injury also occurred in 10-20% of patients with serious head injury, and 1 in 300 serious motor vehicle accidents. Of these fractures up to 14% will be unstable. The rate of missed c-spine injury is low at 0.01%. C-spine injury also occurred in 10-20% of patients with serious head injury, and 1 in 300 serious motor vehicle accidents.

There are two main sets of decision rules to help decide which patients should be imaged. RCEM has its own guidelines based on modified Canadian C-spine Guidelines. If you were thinking that you’re better than the guidelines, think again – this is only 80% sensitive and 73.98% specific.
Spine and Spinal Cord Trauma

NEXUS Guidelines

NEXUS guidelines were the first set of guidelines created. They have a sensitivity of 99.6% with a 12.9% specificity—lower specificity than clinical judgement alone. The NEXUS study was large, and included lots of people, including children.

NEXUS looks at the following five points. If any one of these is present, you should have radiography:

- Focal Neurologic Deficit Present?
- Midline Spinal Tenderness Present?
- Altered Level of Consciousness Present?
- Intoxication Present?
- Distracting Injury Present?

So I think NEXUS is where the approach of “lets poke their neck and if it’s sore get an x-ray” comes from. Midline spinal tenderness as a discriminator has been criticised as anyone has midline tenderness if you push hard enough, especially over C5!

The authors of the NEXUS rules have not defined what a distracting injury is. Some say any pain scoring more than 5/10 on a scale of one to ten. Recent studies suggest distracting injuries are chest injuries, long bone fractures, visceral injury requiring surgeons, large laceration, large burns or any injury producing functional impairment. There’s a nice summary card from AliEM.

Canadian C-spine

The Canadian c-spine rules were validated in adult patients sustaining acute blunt trauma to the head or neck. The study excluded people with delayed presentation (more than 48 hours), known vertebral disease, grossly abnormal vital signs and children. So this means that these rules have not been validated in children.

The Canadian C-spine rule is a three step process. Unlike the NEXUS guideline, it considers high risk factors first:

Anyone over 65, with a dangerous mechanism or paraesthesia mandates radiography. In the age of silver trauma, imaging everyone over the age of 65 has its own challenges.

If there are no high risk factors, safe factors are looked at next. If any one (single) low risk factor is present, range of movement can be assessed. The low risk factors are:

- Simple rear end shunt MVC
- Sitting position in ED
- Ambulatory at any time
- Delayed onset of neck pain
- Absense of midline neck tenderness

So you only need one of these to move on to the next step. You can get to this point without having looked carefully at the patient! It’s really important to ask the patient when the neck pain started!

If they have any single low risk factor, you can then move on to see if they can rotate their neck. If they can, they don’t need radiography!

Once the patient has cleared their own neck, I find it useful to give them a little exercise to do, based on the Feldenkrais method. Ask the patient to rotate their neck and look at what they can see. Then ask them to close their eyes, and imagine what they see when they move their neck. Then they can open their eyes and rotate
their neck again. In the vast majority of people their range of movement improves!! Obviously, only do this once you have cleared their neck, and don’t use it as part of the process to clear their neck!

The NICE guidelines for imaging the c-spine are the Canadian C-spine rules in a different format. The RCEM guidelines use modified canadian c-spine guidelines. They have added two further risk factors:

• Severe neck pain (>7/10)
• Known vertebral disease

Once you’ve decided you can clear the neck, go ahead and treat the patient.

If you can’t clear the neck, discuss with a senior whether to CT or X-ray the patient, as this will depend on the presentation and your departmental protocols. Whether to immobilise the patient or not is another thorny issue – stick with your departmental protocol. Remember, these decision rules are all based on acute presentations – they’re not for the patient who comes to the ED with persisting pain two weeks after trauma.

Want to know more? A learning session was published recently on RCEMLearning. We also have a reference section on the site, if you want to have a look at that.

Clearing the c-spine using Canadian C-spine rules is an integral part of the new ATLS course, and we think an integral part of every day practice. Learn about this by completing our module here, or reading the quick open access reference guide. We focus on the NICE guidelines in a brilliant RCEM podcast segment here. C-spine anatomy is so complicated - there's four vodcasts on it on EMIreland - 1, 2, 3 and 4.

Now consolidate your knowledge with these tantalisingly titled SAQs: Snap - Crackle and Pop, A Kick in the Chest and Humpty Dumpty.
THERMAL INJURIES

Authors: Jonathan Matthews, Rajan Atwal / Editors: Paramjeet Deol, Shashank Patil, Jorge Leon-Villapolos / Codes: CP3AP1e / Published: 30/10/2017 / Review Date: 30/10/2020
Definition & Types of Burn

A burn is defined as a traumatic injury to the skin or other organic tissue primarily caused by thermal or other acute exposures.

There are various types of burns which include:

- **Thermal:**

  This is the most common type of burn and includes flame burns, scalds (from hot liquids) and contact burns (from hot objects e.g. an iron or radiator).

- **Chemical:**

  Alkalis and acids found in household chemical products can produce very deep burns through coagulative and liquefactive necrosis. They will continue to burn the skin until completely removed. It is therefore essential that the skin is thoroughly irrigated. Alkalis penetrate deeper than acids and those presenting with alkali burns (commonly due to cement) will require immediate attention.

Context & Epidemiology

- Burns are a major public health problem globally. In addition to physical damage, they can leave a long lasting psychological and social impact.\(^1,2\)
- In the UK 130,000 people each year visit the Emergency Department with burns injuries.\(^2\)
- Approximately 8% (10,000) of these patients are admitted.\(^2\)
- Although the majority of burns injuries in the UK are not life threatening, there are still around 200 deaths a year.\(^3\)

130,000 PEOPLE EACH YEAR

**Figure 1** shows the causes of burns by type.

**Figure 2** shows the incidence of burns by age.
• **Electrical:**

As an electrical current travels through the body it creates an entry and exit point, damaging tissue along its path as it is converted from electrical to thermal energy. Electrical burns from domestic low voltage exposures tend to be less severe than high voltage electrical burns which can cause extensive tissue damage and limb loss. It is still very important that domestic electrical burns are taken seriously and an ECG is performed as the alternating nature of domestic current can cause arrhythmias.

![Figure 3](image)

• **Cold exposure (frostbite):**

These burns are caused by ice crystals which can form both intra and extracellularly. The subsequent fluid and electrical fluxes cause cell membrane lysis and cell death and a damaging inflammatory process is set up.

• **Radiation:**

Radio frequency energy or ionizing radiation causes tissue damage and the most common type of radiation burn is sun burn. Other patients at risk of getting radiation burns are those undergoing radiation therapy for cancer treatment.

• **Overall, flame injuries are the most common cause of burns, followed by scalds. Electrical and chemical injuries are much less common.**

• **However, the types of burn sustained are different in different groups of people; in children the most common type of burn is a scald, whereas in adults flame burns are the most common.**

**High risk groups in burns:**

• **Children:**

infants and toddlers up to 4 years make up 20% of all patients with burns injuries. Seventy percent of their injuries are scalds due to spilling hot liquids or being exposed to hot bath water. It is important to consider non-accidental injury in this group.

• **Older adults:**

People over the age of 65 make up around 10% of patients with burns. This may be due to slower reactions, mental and physical co-morbidities and immobility. This group tends to have a higher incidence of burns during the winter months.
• Other higher risk groups include:
alcoholics, epileptics, those with chronic psychiatric or medical conditions and those who have a low socio-economic status.\(^1,\text{6}\)

Basic science and Pathophysiology

Burn injuries result in both local and systemic responses

Pathophysiology Local response

Jacksons Burn wound model is made up of 3 zones (figure 3). This helps us to understand the pathophysiology of a burn injury.

• Zone of Coagulation:
occurs at the point of maximum damage i.e. the nearest point to the heat source. There is irreversible tissue necrosis here due to coagulation of proteins.

• Zone of Stasis:

surrounding the zone of coagulation, this area is characterised by decreased tissue perfusion. It is damaged but potentially viable. If the burn is managed incorrectly it can evolve into an area of full necrosis, hence the need for good burns management.

• Zone of Hyperaemia:

the outer most zone as its name suggests is where there is increased tissue perfusion. This is a reversible zone.

Pathophysiology – Systemic

• The release of cytokines and other inflammatory mediators at the site of injury has a systemic effect once the burn reaches 20-30\% of total body surface area.

• Cardiovascular changes

Capillary permeability is increased, leading to loss of intravascular proteins and fluids into the interstitial compartment. Peripheral and splanchnic vasoconstriction occurs. Myocardial contractility is decreased. These changes, coupled with fluid loss from the burn wound, result in systemic hypotension and end organ hypoperfusion.

• Respiratory changes

Inflammatory mediators cause bronchoconstriction, and in severe burns, adult respiratory distress syndrome can occur.

• Metabolic changes

The basal metabolic rate increases up to three times its original rate. This, coupled with splanchnic hypoperfusion, necessitates early and aggressive enteral feeding to decrease catabolism and maintain gut integrity.

• Immunological changes

Non-specific down regulation of the immune response occurs, affecting both cell mediated and humoral pathways.
Initial Assessment and Resuscitation

As with any major trauma, a systematic **ABCDE approach to the primary survey** is critical to ensure that any life threatening issues are not missed\(^9,10\). This will be outlined over the next few pages.

**Assessment, investigation** and **management** occur simultaneously at each stage of the approach. \(^9,10,11\)

Airway

**The airway is at risk by three major mechanisms:**

- Generalized oedema as a systemic response from an increasing burn size and depth can cause swelling of the airway and compromise airflow\(^9,10\).

- Localized oedema as a result of direct thermal damage to the airway can obstruct airflow\(^9\)

- Inhalation injury as a result of heat, smoke or toxic chemicals can cause damage to the airway.\(^9\)
Assessment

Factors that increase the suspicion of airway obstruction or inhalation injury include:

- Hoarse voice
- Carbonaceous sputum
- Raised carbon monoxide (CO)
- Deep facial burns
- A history of burns in an enclosed space
- Respiratory distress/stridor

Airway compromise can develop over a matter of hours and may only come to light when the patient is in crisis.

Breathing

Gas exchange can be compromised for a number of reasons:

- Direct lower airway and gas exchange surface damage from inhalation injury
- Carbon monoxide (CO) can quickly build up impairing oxygen carrying capacity.

Burnt tissues with significant loss of the elasticity in superficial fibres are known as an eschar. This creates a constricting effect and inhibits expansion (figure 11). When circumferential around the chest/torso/neck this can lead to impaired chest expansion and subsequent ventilation.

Management

1. Sit patient upright
2. Any suspected airway injury necessitates senior anaesthetic review to identify and predict deterioration.
3. If indicated, early intubation with an uncut tube prevents the tube moving in the event of further swelling.

Common pitfalls:

Failure to recognise or predict the deteriorating airway.

Figure 10 shows airway change over a period of 1 hour.


Figure 11

Assessment:

- Exposure of the chest to perform comprehensive assessment of ventilation and any injury to the chest
- Prompt assessment of oxygenation with saturation probe.
- Baseline ABG/VBG (if there is a reliable saturation trace) to assess oxygenation, ventilation and CO.
Management

1. Supplementary oxygen to target appropriate saturations of 94-98%\(^9,10\)
2. Immediate discussion with burns center if any restriction of movement of chest\(^9,10\)
3. Suspected inhalation injury may warrant intubation\(^9,10\)

Common pitfalls:

- Failure to recognise rising CO level.
- Failure to recognise poor ventilation and the need for an escharotomy

Top tips:

- Escharotomy can be a lifesaving procedure that relieves restriction of movement and allows chest expansion. This is an emergency situation which will be discussed later
- Cyanide poisoning is common in patients that have been exposed to inhalation of burnt household items. In profound hypoxia consider early administration of cyanokit \(^10\)

Assessment

- A thorough assessment of the extent of a burn is paramount: Burns <15% in adults and <10% in children do not require immediate fluid resuscitation\(^9\)
- Capillary refill time (CRT), blood pressure and mucous membrane assessment are important indicators of hydration status but may be hard to measure due to the location of the burn\(^10\).
- Though rarely immediately helpful in the Emergency Department setting, early catheterization is important as urine output is a reliable sign that can demonstrate poor perfusion and serve as a guide to ongoing resuscitation\(^9,10,13\).
- In a significant burn there can be an increased metabolic demand on the patient which can cause organ dysfunction. Therefore, important baseline tests to consider are full blood count, urea and electrolytes, coagulation profile, liver function tests, amylase, C-reactive protein and capillary blood glucose. This also helps to identify any other issues impacting on the patient. If the patient is likely to go to theatre a serum group and save is warranted.
- In circumferential limb burns, blood supply to the extremities should be checked regularly. If unable to do this clinically, a Doppler ultrasound can be used\(^9,10,11,13\).

Circulation

- Burns >15% BSA in Adults and >10% in children can cause profound circulatory shock that can occur from both large fluid losses through tissue damage and from a systemic inflammatory response\(^10\).
- Haemodynamic instability is rarely due to the burn alone and should prompt us to look for other causes
- Circumferential limb burns can compromise blood supply distally

Management

1. Immediate intravenous (IV) access and, if required, fluid resuscitation are critical steps in initial care\(^9,10,11,13\).
2. Blood tests
3. Evaluate any areas of circumferential burns in limbs and regularly reassess perfusion
4. Any deterioration in the circulation to a limb could indicate ischemia or a compartment
syndrome. This warrants immediate discussion with a burns centre and may require urgent intervention such as escharotomy or fasciotomy\(^9,10\).

**Top Tips**

- IV access is paramount. If it is not possible to get IV or IO access through unburnt skin, access is mandated through burnt tissue.
- Creatine kinase is a useful test to perform to assess muscle breakdown\(^9\).

**Disability and exposure**

Like any trauma patient disability and exposure cannot be ignored.

Appropriate exposure is fundamental for the assessment of patients with burns. A thorough assessment of size and depth of burns is impossible without full exposure and a good secondary survey\(^9,10,11,13\). However patients with burns are physiologically vulnerable to getting cold so it is critical to keep them warm and minimize fluid loss\(^9,10\).

**Management**

1. Consideration should be made to maintain body temperature by both active and passive warming\(^5,10\). This is balanced with the need to adequately expose the burn in order to assess, photograph and clean\(^10\).
2. Clean the burn with normal saline and cover with strips of cling film. Do not use cling film on the face.
3. Consider imaging e.g. X-ray, CT etc. based on findings of the secondary survey

**Common pitfalls**

- Missing other injuries not related to burns e.g. traumatic head injury or long bone fractures in a blast injury
- Failure to give adequate analgesia

**Top tip**

- Have all members of the team present during exposure of an area to simultaneously evaluate and photograph the areas to avoid repeated unnecessary exposure and heat loss

**Analgesia**

The burning process is exceptionally painful and analgesia should be given early. Both pharmacological and non-pharmacological methods should be used to control pain.

- Non-pharmacological methods include cooling the burn under cold running water and covering with cling film. Cling film also helps to reduce heat loss and the risk of infection.
- Pharmacological treatment includes simple analgesia such as paracetamol and NSAIDs, as well as stronger analgesia like opioids and ketamine.

**Assessing the extent of a burn**

In order to guide management goals it is important to assess both extent and depth of the burn. In order to assess the extent of a burn it is vital to expose all areas to accurately estimate correct % BSA affected. This can help:

- Predict the physiological response the body will have to the burn
- Calculate the fluid requirement during the initial resuscitation period
- Burns are graded into Severe and Non Severe according to the physiological effect exerted on the body\(^11\).
  - Severe burns are defined as a >10% BSA in a child and >15% BSA in an Adult\(^10\)

Common tools of estimating % burn of BSA are:

- Lund Browder charts published charts at different ages estimating how much % of BSA each body sector equates to\(^5,12\) – figure 12a
• Using the patient’s palm (not examiner’s) with the fingers and thumb adducted, as an estimate of 1% of BSA\textsuperscript{9,10}

• Using an estimation of each body sector as either 9% or a multiple of 9% See figure 12b

• Mersey burns app (figure 13) – Interactive app enabling the user to highlight areas of burn tissue on a model to accurately estimate the % BSA affected\textsuperscript{14}

**Mersey Burns App**

• Accurate estimation of % of BSA

• Intuitive and usable\textsuperscript{15}

• Calculates appropriate fluid requirement directly from the app

• Recommends referral criteria

**Top tip**

• Epidermal burns are not included when calculating the size of the burn

**Assessing the depth of a burn**

To make an accurate assessment of the depth of a burn, skin needs to be cleaned, blisters removed (except for small non-tense blisters \(<6\text{mm}\)) and capillary refill time tested.

Guidance on which blisters to de-roof and how to do it by the London and South East of England Burn Network (LSEBN) can be found here.

**Blister Management**

**Blister Deroofing**

The depth of the burn can be classified into 1 of 4 types. The British Burn Association (BBA) accepted definition has replaced the older 1st, 2nd and 3rd degree classification.

Ref: Modified from ncbi
## Thermal Injuries

<table>
<thead>
<tr>
<th>Depth of Burn</th>
<th>Layer of skin affected</th>
<th>Clinical Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Epidermal Burn</td>
<td>Epidermis only</td>
<td>Skin is red and painful, but not blistered. This is typical of sun burn.</td>
</tr>
<tr>
<td>Superficial Partial Thickness Burn</td>
<td>The epidermis &amp; upper layer of dermis.</td>
<td>The skin is pale pink and painful with blistering. Capillary refill: blanches &amp; rapidly returns.</td>
</tr>
<tr>
<td>Deep Partial Thickness Burn</td>
<td>The epidermis, upper and deeper layers of dermis</td>
<td>The skin appears dry or moist, blotchy and cherry red, and may be painful or painless. There may be blisters. Capillary refill: blanches with a sluggishly return or does not blanch.</td>
</tr>
<tr>
<td>Full Thickness Burn</td>
<td>The burn extends through all the layers of skin to subcutaneous tissues.</td>
<td>The skin is dry and white, brown, or black in colour, with no blisters. It may be described as leathery or waxy. It is painless. Capillary refill: does not blanch.</td>
</tr>
</tbody>
</table>

[Table adapted from reference 7 & 8]
In clinical practice burn wounds are not homogenous but often are of mixed depths, as shown in Figure 15.

![Figure 15](Property of Burns unit, Chelsea & Westminster Hospital)

The white areas are Full Thickness burns (FT), with the deeper red and paler pink areas showing Deep Partial Thickness (DPT) and Superficial Partial thickness (SPT) burns respectively.

**Fluids**

Patients with severe burns (> 10% in a child and 15% BSA in an adult) have a significant fluid requirement. There are a number of methods to calculate appropriate fluid replacement. One of the most used is the Parkland equation\(^9,10\):

\[
2-4 \text{mls} \times \% \text{BSA of burn} \times \text{weight in kg}
\]

This estimates the recommended total fluid administration over 24 hours. Half of this volume should be administered over the first 8 hours from the time of the burn. This fluid, ideally a warmed physiological crystalloid e.g. Hartmanns should be administered in addition to the maintenance fluids. Careful monitoring is paramount as adjustments may be needed to achieve an appropriate urine output of 0.5ml/kg/hr\(^9\).

**Management of the burn wound**

**REMOVE:**

Remove loose clothing, but do not remove anything that is adherent or melted.
Thermal Injuries

COOL:

Irrigate and cool thermal burns with cold running tap water for 20 minutes. This can be beneficial up to 3 hours post burn injury.

Irrigate chemicals from skin/eyes immediately with warm running water for at least 15 minutes
Do not use ice/iced water/ice packs

COVER:

Clean the wound with normal saline and cover the thermal burn with loose longitudinal strips of cling film
Do not use cling film on the face

Cover the chemical burn with a wet compress

Tetanus status needs to be determined and adequate cover given

Special Circumstances

- In certain circumstances it is recommended patients are discussed with and referred to the local burns centre. Figure 16 highlights some of these circumstances.

- An important one not to miss is non-accidental injury (NAI). It should always be considered in paediatric presentations and particular attention given to whether the history is consistent with the pattern, location, and type of burn seen. Elderly patients are also at risk of NAI.

- Toxic shock syndrome (TSS) is another key situation to discuss with the local burns service. Any patient, with any size burn, with any of the symptoms below are at risk:

  • Temperature > 38°C
  • Rash
  • Diarrhoea & vomiting
  • General malaise
  • Not eating or drinking
  • Tachycardia/tachypnea
  • Hypotension
  • Reduced urine output

Adapted from LSEBN: Burns referral criteria
When referring to a burns centre the national burns image transfer website TRIPS provides a safe and secure method for sending images.

**Escharotomy**

With Full Thickness & Deep Partial Thickness Burns, the dermis can become very stiff. If this occurs circumferentially over the chest it can restrict chest wall movement and lead to mechanical respiratory failure. Equally if there are circumferential burns to the limbs this can cause limb ischaemia. In these cases an emergency escharotomy needs to be undertaken to release the rigid skin to allow: adequate ventilation (if the chest is involved) or circulation (in the limb).\(^\text{19}\)

The process of the dermis stiffening takes time and the majority of patients requiring escharotomies often go to theatre for this at a later stage. However, knowledge of the procedure can be life and limb saving in the emergency setting.

**Procedure:**

- The limb should be kept in the anatomical position.
- The area is cleaned and incised along the anatomical lines (see figure 11) with a scalpel down to the fat
- The incision should not go down to the muscle or fascia
- For the limbs the incisions need to release both medial and lateral aspects
- For the chest the incision needs to release the whole breast plate

---

**Figure 11**

The UK seems to have seen every end of the weather spectrum recently, and RCEMLearning is here to help you manage it! We have modules on hypothermia and frostbite and burns, and podcast segments on non accidental burns and burns in general, and references that you may find useful are Hypothermia & Heat related illness

As external resources, we'd recommend looking at all the London Burns Network Guidelines, and the Mersey Burns app.
PAEDIATRIC TRAUMA

Authors: Charlotte Davies and Nikki Abela / Code: PMP4 / Published: 27/11/2017
Children's bones are more compliant.
So any rib fracture indicates a significant force was used.

Airway

Children tend to have a larger tongue, smaller jaw and shorter, narrower, funnel-shaped airway with an anterior larynx. This means that the tongue is more likely to block the airway than in adults. Moreover, the occiput is more prominent meaning that “at rest” their neck is flexed and their airway closed. The narrow airway also means that a very slight amount
Paediatric Trauma

of oedema leads to significant airway compromise and resistance 1mm of oedema can reduce a patient's airway by 60% (You all remember Poiseuille’s law no?).

Foreign bodies are more likely to go through the cords and get stuck at the cricoid, whereas in adults, foreign bodies are more likely to get stuck in the cords. Depending on the age of your patient, they may be losing their primary incisors which may be your foreign body, or they may be loose or missing affecting your airway management further.

The airway is short, and easily blocked – you might need to put a cushion underneath the shoulders to maintain neutral alignment.

Because the airway is short, if you are intubating, a main bronchus intubation is likely so its really important to do your calculations right and watch the black line on the ETT pass through the cords.

C-Spine

Children have very flexible and elastic spinal ligaments, so there is a lot of c-spine movement. Their vertebrae are anteriorly wedged with flat facet joints. This combined with their large head, means that children have a relatively high fulcrum, and the spine moves a lot, with lots of forces being applied to C1 and 2.

Although abnormalities between C1 and 2 are more likely, pseudosubluxation is also seen here between C2/3 (24% < 8yrs) and C3/4 (14%). It can be difficult to tell the difference between true subluxation and injury, and a pseudosubluxation. Swischuks Line can be useful – this is a line drawn between the posterior arch of C1 and C2. It is a dislocation if line misses the anterior cortex of C2 by > 2 mm. I think I'd be speaking to my friendly radiologist about this.

Collars are unlikely to help immobilise the c-spine in children, and their use in children is not routinely taught on APLS who suggest manual inline immobilisation, followed by blocks and tape when necessary.

Due to the increased risks associated with irradiation, particularly to the thyroid gland, and the generally lower risk of significant spinal injury, CT of the cervical spine probably should NOT ROUTINELY be used and there is more covered on this here. Our local MTC guidelines suggest the standard 3 x-rays in children >10, and in <10 year olds, lateral and AP only.

The Royal College of Radiology guidelines also do not suggest the routine use of CT c-spine in the paediatric population, with exceptions:

- You are doing a CT head and are worried about the C-spine
- A GCS less than 13 or patient is intubated
- Focal neurological signs.
- Definitive diagnosis of cervical spine injury is needed urgently (for example, before surgery).
- Another body area scanned
- There is strong clinical suspicion of injury despite normal X-rays.
- Plain X-rays are technically difficult or inadequate.
Paediatric Trauma

The RCR instead suggest early neurosurgical involvement. They also suggest that C1-3 is included on a head CT, as this is a high risk spot for injury. Interpreting images can be difficult – phone a friend!

Breathing

Children have a very soft, pliable chest wall meaning that pulmonary contusions without rib fractures are possible. Because children’s bones are more compliant, forces applied across the chest wall will cause movement and then recoil.

Children also have horizontally aligned ribs and weak intercostal muscles, so rely more on diaphragmatic breathing than adults. A tension pneumothorax is more likely due to their very mobile mediastinum.

Children swallow a lot of air, especially when screaming. This can cause gastric dilatation, which in turn can cause an ileus.

When interpreting the CXR, if this is normal, the patient is conscious and clinically stable, a CT is unlikely to be indicated in blunt trauma.

This means we have to carefully evaluate the chest – we might not see evidence of pulmonary contusions, and we must think twice about whether there is a tension pneumothorax.

Due to the risk of vascular injury, CT is indicated as the primary modality in penetrating trauma.

Circulation

With a smaller circulating volume, children obviously have a lot less blood to lose- so seemingly small losses to an adult may mean a big deal to a child. Their stroke volume is pretty fixed and therefore the only way of increasing their cardiac output is to increase their heart rate so pay attention to a tachycardia.

What’s worse than small circulating volumes, is that they are also more likely to lose it from their lower-riding liver and spleen, that is not protected well from their softer, thinner, abdominal wall (less musculature, less fat, more square abdomen). It’s not just their upper abdominal organs which are more exposed, the bladder is also an intra-abdominal organ in young children (and lies at the level of the umbilicus at birth) so is especially vulnerable.

The intestine also, especially the sigmoid and right colon, are not fully attached in the peritoneal cavity in young children and are more likely to be injured with forces of compression or sudden deceleration.

The Holmes prediction rule can help us to know if children need abdominal imaging or not:

This means we have to examine the abdomen carefully for bruising, and remember that the bladder, spleen and liver have minimal protection against trauma. Blunt renal trauma is also more likely as children have less protective perinephric fat, and the kidneys are relatively large compared to the rest of the abdomen. Significant haematuria should be taken seriously and investigated further.
Paediatric Trauma

Not only, but once found, an abdominal injury should alert the physician to re-examine the spine. Don’t forget that Chance fractures, a.ka. seatbelt fractures, are commonly associated with abdominal injuries. They are flexion-distraction type injuries of the spine, that typically come about from a poorly restrained (lap-belt only) RTC. They involve all three spinal columns and are unstable injuries.

Thankfully, pelvic fractures are rare, but if suspected they are harder to splint – SAM splints are hard to cut to size, prometheus on the other hand are fairly easy.

Disability

Because the head is so much bigger, the chance of injury is increased in the paediatric population.

In younger children, the cranium is softer, with open fontanelles (until 12 – 18 months), so it is possible to get significant injury, with minimal external signs. Because their craniums aren’t closed, this means there is extra space for haemorrhage to expand into, meaning a significant injury can hide there without causing a decreased GCS or signs of increased ICH. Don’t forget to palpate the fontanelle, look inside and behind the ears (the younger the child, the less there is to go on so make the most of your examination), and observe the child if needed. The NICE guidelines for head injury are commonly used, and are a good guide for imaging. If sending the parents home, do safety-net appropriately if this is late in the day, I do sometimes advise the parents (with little evidence) to rouse the child overnight to make sure they are ok.

Children also have a higher body surface area to mass ratio with thinner skin and less insulation by subcutaneous tissue so might get cold a lot more quickly than adults-cover them up and warm them appropriately.

Exposure

Exposure is also key to picking up multiple injuries in cases of non accidental injuries, and therefore a careful A-E assessment must be done. Remember, non-verbal children can’t tell you what’s happened to them, and it’s your responsibility to double check the history you’ve been given.

However, if faced with a paediatric trauma, it’s safe to allow the voice of Ross Fisher’s excellent talk at RCEM & EUSEM conferences echo in your mind “paediatric trauma is different”, but the primary survey is not terribly different if you are aware of their anatomy. Mentally rehearse your actions, and you will be fine.

Further reading:

PedEmMorsels: Chance fractures
Paediatric Anatomy and Physiology and the Basics of Paediatric Anaesthesia
Paediatric wound management
Brackium emendo long bone and nai

We love the little people don’t we! We’ve got some podcast tips and hints on paediatric trauma imaging, analgesia, and recognition of child abuse in the ED.
GERIATRIC TRAUMA

Author: James Wallace, Dave Raven / Codes: HMP3, CMP3 / Published: 22/05/2018
Geriatric Trauma

THE POPULATION IS GETTING OLDER

Adult priority call, 3 minutes. You read the ambulance hand over, and tut to yourself. 90-year old lady, fallen down the stairs, normal observations. You wonder why they’re bothering to pre-alert you, after all her observations are normal. You read down, and your SHO peers over your shoulder. “Oooh, silver trauma” they say. You realise, maybe, you should not put out that priority call; maybe you need a trauma call instead.

The world’s population is getting older, more dependent on healthcare and is presenting in greater numbers to our emergency departments with complex medical, social and traumatic complaints. Trauma training and triage have traditionally been based upon the mechanism and injury patterns, with outcomes of operative intervention, massive transfusion and mortality.

Mechanisms for serious injury and trauma outcomes differ subtly compared to the younger trauma patient, and our older trauma patients may still receive injury-based care, rather than holistic patient-centred care if their injuries actually get recognised and treated.

For example the 90-year old lady that trips in the garden and sustains a fractured neck of femur will be placed on a well-recognised pathway that will eventually have ortho-geriatric input. However, there may not be any early review of the postural hypotension that caused the fall, the delirium causing her to take the bins out at 0300 on a February morning, or that she’s mistakenly taken too much warfarin the night before because her main carer/husband has just been admitted to respite care.

Care of the older trauma patient should be patient centred, not injury centred.

What is an older patient?

Older age has always been sociologically defined as 65 or retirement age. The International Consortium
on Health Outcome Measures defines older age as the last ten years of life before regional life expectancy. So a patient in parts of central London would be defined as older at 80, but a patient in parts of the North of England would be older at 70.

Frailty is also another description that is commonly and sometimes incorrectly associated with older patients. It is quite possible to be aged 20 and frail, but also aged 90 and not be frail. There are many studies looking at whether frailty is a better predictor for outcome than age in older trauma patients.

Physiology and outcome

Most prehospital and in-hospital trauma triage are based upon mechanism, injuries sustained and some physiological parameters, with various outcomes such as need for surgical intervention and mortality. Our older patients have not only a different pattern of injury and more occult injuries but the physiology of ageing may not have the traditional parameters to trigger major trauma pathways.

Older patients may have underlying hypertension, are less able to respond to hypoperfusion and are more likely to have heart rate controlling medication. Therefore, higher systolic blood pressures and lower heart rates may be a sign of hypoperfusion which, combined with reduced elasticity of blood vessels and organs leads to increased potential for occult and devastating haemorrhage.

For those patients who are in the last few years of life, increased mortality may not be the most appropriate outcome measure but perhaps quality of life, length of inpatient stay, risk of iatrogenic injury, need for permanent care and permanent disability would be applicable.

What has changed

The most recent TARN report on older persons' trauma showed that we under triage both pre and in-hospital, do not place as many trauma team activations, have less senior reviews of older trauma patients and that the commonest mechanism for an ISS >15 was a fall from own height, with the head and thorax being the commonest body areas injured.

Several international centres have looked at different models for older persons trauma triage, using different physiological parameters and mechanisms to trigger a more senior review or trauma team activation. They essentially reduce the mechanism to trigger a trauma transfer or activation, incorporate other past medical factors such as lung/cardiac disease and anticoagulation as well as changing the abnormal parameter threshold for trauma team activation.

The Midlands Silver Trauma Group has proposed a Silver Safety Net, to try and improve the prehospital pre-alerts for older people with traumatic injuries. This is designed to assist identifying the most appropriate method of conveyance to an MTC or trauma unit, with a silver trauma pre-alert to highlight the potential need for early intervention and/or imaging but who would not need a formal full trauma team response. The group run a very informative course on Elderly Trauma and ongoing recovery at multiple sites across the country.

Aftercare

The care of an older trauma patient doesn’t stop in the ED- it begins there and should continue in a multidisciplinary manner throughout their stay. Whilst EM physicians may not be trained in the use of comprehensive geriatric assessments, we do begin the process during our clerking of medically unwell patients and there’s a plethora of simple tools available from our physio/occupational therapy/pharmacist colleagues that can be used as part of the initial trauma clerking to assist getting older patients back on their feet, prevent iatrogenic injury and reduce length of stay.
Pitfalls

Delirium is very commonly missed in older trauma patients, and commonly presents in hyperactive or hypoactive states. Multiple medications, especially analgesics can contribute to delirium and other trauma induced positional complications such as atelectasis with chest wall injury, constipation and pressure sores from dehydration. The STOPP START toolkit is very useful for reviewing medication in older patients, as well as early involvement of pharmacists for polypharmacy reviews.

Summary

• There are more older patients sustaining trauma and EM physicians are in the perfect place to get their care right from the outset

• Falls from own height and head injuries are the commonest causes for high ISS and mortality

• Older patients have reduced physiological reserve to respond to traumatic insult, but their observational parameters may not show it

• Patient-centred care is more important than injury-based care

• Have a lower threshold for senior review and activation of a silver trauma team

• Older trauma patients need an MDT approach earlier in their stay

• The CGA and discharge planning can start at triage

• Beware polypharmacy and delirium

Further interesting reading:

Geriatric Trauma RCEM Conference Podcast
Trauma – mention of silver trauma
TARN Major Trauma in Older People 2017 report
HECTOR course Heartlands Elderly Care Trauma & Ongoing Recovery
British Geriatrics Society Silver Book Quality care for older people with urgent & emergency care needs
STOPP START Toolkit: Screening Tool of Older People’s potentially inappropriate Prescriptions and Screening Tool to Alert doctors to Right Treatments.

Geriatric or silver trauma is increasing in awareness. We've talked to a few experts in our podcasts - one back in 2017, and one more recently in 2018. Both cover different aspects of trauma care, and are worth a listen! If you fancy learning about silver trauma through the eyes of a geriatrician, pop over to MDTea.

There's lots of external guidelines and links around - have a look at the London guidelines and the Leicester guidelines.
There are lots of skills around managing trauma. Here are a few of the resources we have to help you:

### Trauma in Pregnancy and Intimate Partner Violence

Emergency contraception may not instantly seem linked to trauma. For more about domestic violence, listen to our guideline update.

### Transfer

Handover is an important part of transferring patients, and we'd recommend deliberately practicing this skill so that you get better, and better, and better. We have a podcast on handover, and would also recommend entering the resus room to listen to what they have to say.

### Ocular Trauma

Significant ocular trauma isn't very common - pop to RCEMLearning to refresh yourself on your initial assessment, and management of corneal abrasions. Then have a look at ophthobook for the "exploding eye" video!

### Mass Casualty

Mass casualty incidents have become increasingly common. These two podcasts (1 and 2) were written before the Manchester bombing, Grenfell tower, Croydon tram crash, London Bridge terror attacks, but still worth a listen.

### Disaster Preparedness, Triage, Trauma Team Management

We don't have any resources on this - contact us if you'd like to contribute some!

### Trauma Skills

- Ultrasound is useful and we have some great modules.
- Traumatic Cardiac Arrest isn't managed according to ALS - have a listen to our podcast.
- Thoracotomy: We have two audio guides to a thoracotomy found here and here.

- Chest X-ray interpretation in trauma is covered in this module.

RCEMLearning had lots of publications about trauma that didn't fit anywhere else. If you're interested in trauma, have a look at them - but remember that some of them are a little old.

### Musculoskeletal

Tetanus management has changed since this podcast was recorded, but we still think its worth a listen as it explores some of the issues around vaccination. When you've done that...what can you learn in 5 minutes? Let EM in 5 talk you through femur fractures.

Then consolidate your knowledge by looking at SAQ one and two, and these x-ray carousels on knees and feet.

### SAQ:

- Chainsaw injury

### Podcasts:

- RCEM Guideline; Information sharing & Community Violence
- Top 10 Trauma Papers 2014-15
- More than just a trauma conference
- Trauma podcast with Andy Neill and Jon Jones Part 1
- Trauma podcast with Andy Neill and Jon Jones Part 2
- Lessons learned from major trauma with Jon Jones
- Cutting Edge Advances in Major Trauma Care 2015
- IR in trauma
- Aggressive PHEM
- Impedance Threshold Device in trauma
- LTC Podcast 6 Prehospital ECMO
- LTC Podcast 4 – Trauma Nursing & Research
- LTC podcast 3; 25 Years between, through and over the hedges of Ireland
- REBOA

And of course it's not just us who have great trauma resources. Have a look at St Emlyn's, and your local trauma network's guidelines (for us, that's selkam).